Integration and inference in understandig causal sentences

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Integration and inference in understanding causal sentences

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Reinier Cozijn   Tilburg, 2000

Aan mijn moeder

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CHAPTER 1

Introduction

The goal of reading text is, obviously, to understand what the text is about. This is a very complex task indeed. Texts consist of letters, words, clauses, and sentences, each at a high level of complexity. These informational units form the basis for the construction of a representation of the text in memory. However, the extraction of these informational units alone is not sufficient to obtain understanding. Successful understanding comes about by building relationships between these units and integrate them with the reader's knowledge. Only then will the representation of the text be perceived as coherent.

Not all relationships between the various units of the text are explicitly stated. Very often, they are left implicit and have to be derived or assumed on the basis of the text. Such an implicitly derived or assumed relationship is called an inference. In a less strict sense, the term 'inference' is used for all kinds of information that is computed from text or retrieved from memory and that is not explicitly stated in the text.

Inferences play a very important role in studies of discourse processes and text understanding. One can say that the process of making inferences is tantamount to the process of understanding. As Schank put it in 1976, the inferential process constitutes the "core of the understanding process" (Singer, 1988). Or, in the words of Sanford (1990, p. 515): "The ubiquity of inferences in text comprehension makes the study of text comprehension look like a subset of the study of inference making." That inferences are ubiquitous can easily be illustrated by a simple example. Take the following two-sentence text:

> Meira cried.
> She had been forced to give half of the chocolate bar to Adrian.

In order to understand these sentences readers will infer that 'She' in the second sentence refers to 'Meira' in the first sentence. The pronoun 'She' refers to an entity introduced earlier in the discourse and 'Meira' is the only candidate. From this inference, it follows that 'Meira' is female, since the pronoun 'She' is female, but probably most readers have already inferred her gender on the basis of their knowledge of girls' names alone (by the same token, 'Adrian' probably is considered to be male). It then has to be inferred that 'She' ('Meira') is in the possession of a chocolate bar. The definite article 'the' in 'the chocolate bar' is not indicative of possession but the verb 'give' is. The verb implies that the agent of giving has possession of what is given. The two sentences form a coherent sequence if one infers that Meira cried **because** she had to give half of the candy bar to Adrian. This causal inference is based on our knowledge of the state of affairs in the world where being forced to part with something dear is considered to be unpleasant and leads to unhappiness. The verb 'cried' in the first sentence, therefore, is interpreted as 'wept' and not as 'shouted.' The fact that the reason for crying in this inferred causal relationship is the giving of a candy bar elicits the inference that 'Meira', and probably 'Adrian', too, are children. Finally, the reader will be able to deduce from the second sentence that 'She' was left with half of the chocolate bar.

From this simple example, it is obvious how pervasive inferences are and also how diverse they are. Inferences differ in many aspects, for example in the kind of processes that are involved. The resolution of a pronoun is a completely different process from, for instance, the causal linking of the two sentences, or the logical deduction that one of the actors was left with half of the chocolate bar after the split-up. Another source of diversity is the moment during reading at which inferences occur. The inference of pronoun resolution in the present example can be made at the moment the pronoun is processed but the causal relation as well as the logical deduction can only be made after the second sentence has been read. Furthermore, inferences differ with respect to the kind of knowledge that is needed to make them. The resolution of the pronoun is based on knowledge about the language; the causal relation is based on knowledge about the state of affairs in the world; and the logical deduction is based on knowledge about logic or calculus. Yet another aspect that differentiates between inferences is the nature of their contribution to the discourse representation.

The pronoun 'She' must be resolved in order to fully understand the second sentence. Its resolution contributes to the coherence of two sentences. A similar statement can be made about the causal inference. When the two sentences are causally connected, the second as cause for the first, their representation is more coherent. The logical deduction, however, does not contribute to a more coherent representation in any way. Effectively, there is no need to make this inference, since it would only make the discourse representation richer, or more complete. Another aspect in which inferences differ is their direction. The anaphoric resolution and the causal relation are made in a backward direction. They connect information in the sentence in which they occur with previously processed information in the discourse. The logical deduction inference in the example, on the other hand, if made at all, is not based on a connection with earlier discourse. One could say that it anticipates eventualities in the subsequent text, and thus can be called, in terms of direction, forward. Finally, inferences can be said to differ with respect to the extent to which they are authorised by the text. In this sense, the logical deduction about the remaining half of the chocolate bar can be derived from the second sentence as a necessarily true implication. This inference cannot be negated without a contradiction resulting. On the other hand, the causal linking of the two sentences does not follow necessarily from the text. It is a possible relation between the events described in the two sentences and negation of this inference need not lead to a contradiction.

This short exposé of inferences on the basis of the textual example is but a selection of the types of inferences that have been distinguished in reading comprehension research. Many more types of inferences have been found and investigated. Their multitude, their diversity, and, of course, their importance to discourse comprehension have led several researchers to attempt to make classifications (Garnham, 1989; Kintsch, 1998; Singer, 1988; Singer, 1994; Vonk & Noordman, 1990). A classification should help in establishing the characteristics that determine when what type of inference is made during reading. Singer (1988) classified inferences on the dimensions logical versus pragmatic, forward versus backward, type of implied relation, and implicational probability, all of which have been illustrated above. These categories, however, apart from not being orthogonal, are not very helpful in answering the question of what inferences are made during reading. The reason, according to Garnham (1989), is that classifications based on form or content of the inferences have no bearing on the language processing system and, consequently, are of little psychological use. He suggested a classification based on the function of the inference, i.e., whether it is necessary for comprehension or is merely an elaboration. Vonk and Noordman (1990) criticised the notion 'necessary for comprehension' as a classifying term. Comprehension is not a well-defined notion. One can understand a sentence or a text at different levels (more or less deeply) and these differences partly depend on the number of inferences that are made. The number of inferences, therefore, (co-)determines the depth of comprehension achieved. At what level of comprehension can a contributing inference be said to be necessary? To avoid this problem altogether, they proposed a classification of inferences on the basis of the information that is inferred from the text. From this perspective, inferences are categorised on two dimensions: deducibility and type of contribution to the representation, or, in other words, where they come from and what they lead to. On the first dimension, inferences can be classified as necessary or as probable implications of sentences in a text. The second dimension refers to the contribution inferential information can make to the representation of a text. It can contribute either to the coherence or to the completeness of a text representation.

This last distinction is generally considered the most important factor in determining whether or not inferences are made during reading. Inferences that contribute to representational coherence are believed to be made during reading, whereas inferences that contribute to representational completeness need not be made. Several other distinctions have been proposed in the literature that have a strong relationship with the dimension of type of contribution. In the backward-forward distinction, for instance, backward inferences, which are found to be made during reading, very often contribute to coherence, whereas forward inferences, which normally are not made, contribute to completeness. A similar comparison can be made with the distinction between bridging and elaborative inferences. There are several other factors that influence inferential processing, however.

Singer (1988) presented an overview of factors that influence the making of an inference. He divided the factors into two categories, namely those that pertain to characteristics of the text and those that bear on characteristics of the reader. Textual factors concern the question whether the inference contributes to the coherence of the text or to the completeness of the text (see above), whether the information to be inferred is thematic and important or peripheral and unimportant, whether the distance between the textual elements to be connected is short or long, and whether the information to be inferred is interesting or not. Factors concerning the reader are the task or the goal set by the reader or by someone else, and the prior knowledge the reader has about the subject of the text.

Inferences are said to contribute to the coherence or the completeness of the text representation. But what actually constitutes a text representation? In reading-comprehension research, it is generally assumed that readers build a representation of the text, consisting of three levels: a surface representation, a propositional representation, and a mental model representation (Fletcher, 1994; Johnson-Laird, 1983; Kintsch, 1998; Van Dijk & Kintsch, 1983). Several studies have shown the feasibility of this distinction (Bransford, Barclay, & Franks, 1972; Fletcher & Chrysler, 1991; Glenberg, Meyer, & Lindem, 1987; Morrow, Bower, & Greenspan, 1989; Kintsch, Welsch, Schmalhofer, & Zimny, 1990; Perrig & Kintsch, 1985; Schmalhofer & Glavanov, 1986). At the surface level, the literal wording of the text are stored. This superficial, verbatim text representation is transient in nature, in that it vanishes rapidly from memory. At the propositional level, it is assumed that the semantic content of a text is represented. The meanings of words, clauses, sentences, and their interrelationships are encoded and stored in memory. The unit of analysis at this level is the proposition (Kintsch, 1983). A proposition consists of a relational term or predicate and one or more arguments. Arguments may be concepts or other propositions. The representation of semantic content in the form of propositions results in a propositional network or textbase. It stays in memory for a considerably longer time. Like the surface level representation, the propositional representation is assumed to be textually bound, that is, its content is strictly tied to the wording of the text. It is this characteristic which distinguishes this representation from the third level, the mental model representation. At this level, a representation of the situation described by the text is constructed. Together with the reader's prior knowledge of the subject of the text, textual information is integrated into a mental or situation model. This model is not restricted to textual information only, but extends to other knowledge domains as well, e.g., to the visual or the spatial domain. It is similar to the representation that would result from directly experiencing the situation that the discourse describes (Fletcher, 1994). The information contained in a mental model representation is shown to be remembered best.

Theoretically, inferences can contribute to all three levels of representation but most research on reading comprehension is directed at the investigation of inferences that contribute to the mental model representation of the text. This is true of the present study as well.

1.1 Theories of inferential processing

An important question in the study of inferential processing is which inferences are made on-line, that is, during reading. McKoon and Ratcliff (1992) proposed a minimalist hypothesis toward on-line inference making. According to this hypothesis, the only inferences that are made on-line - in the absence of specific, goal-directed strategic processes - are those that establish local coherent representations of the parts of a text that are processed concurrently and those that rely on information that is quickly and easily available. The hypothesis has been criticised for not being specific enough about the terms *local coherence* and *easily available*. In the absence of sufficiently specific definitions, it is unclear which on-line inferences the hypothesis actually predicts and which it does not. Albrecht and Myers (1995) proposed a reading model in which inferences follow from a resonance process of concepts and propositions in the discourse representation with those of the current input. The resonance process is influenced by the strength of concepts in memory and the degree of match to the input. This framework allows for the explanation of the occurrence of on-line inferences that contribute to local coherence as well as to global coherence.

A completely different approach to inferencing comes from Graesser, Singer, and Trabasso (1994). In their constructionist approach, they posit the reader as a problem solver who is actively engaged in a search for meaning. This search is assumed to be led by the reader's goals, the need for local and global coherence, and the need for an explanation of the actions, events, and states that are mentioned in the text. Their theory predicts superordinate goal inferences, thematic inferences, and inferences relating to the protagonist's emotional states, to be made on-line. A similar stance is taken by Van den Broek (1994), who hypothesises that the reader is guided by the need to maintain sufficient explanation for the events encountered in the text. In this view, inferences that provide causally sufficient explanation for the focal event are made on-line.

The main difference between the minimalist and the constructionist approaches is that the former stresses the role of the information contained in the discourse representation, whereas the latter stresses role of the information that the reader brings to bear. In a simplified sense, the former theories can be seen as bottom-up approaches to inference generation and the latter as top-down approaches. However, what stands out as a crucial criterion for on-line inference generation is that the reader is knowledgeable about the inferential information.

This common characteristic of theories of on-line inference generation is central to the view of Noordman and Vonk (1998). In their approach, the two types of theories mentioned above can be seen as representing two complementary aspects of memory-based text processing (see also Myers & O'Brien, 1998; McKoon, Gerrig, & Greene, 1996). They consider reading to be a pattern-matching process where propositions in the input are matched to propositions in the memory representation of the previous discourse but also to knowledge structures in long-term memory. This matching process is defined in terms of resonance. Whereas discourse propositions in working memory resonate in a bottom-up fashion with the current input, long-term memory structures resonate in a top-down fashion. Noordman and Vonk point out that the resonance process is a dual pathway: The words in the text resonate with knowledge structures in memory which in turn resonate with the input determining how the processing of the words takes place.

The controversy between the theories of inferential processing shows that the matter of when inferences are made on-line is not resolved. What has been well acknowledged, however, is that for a comprehensive model of reading comprehension a thorough understanding of inferential processing is a prerequisite.

The theories seem to agree on several points as well. Two of them are taken up here. Firstly, it is generally assumed that contributing to the coherence of the discourse representation is an important factor in determining whether inferences are made on-line. Secondly, agreement exists on the importance of the reader's knowledge for the on-line generation of inferences. These two factors and their interplay are the topic of the present study. They will be investigated in psycholinguistic experiments on the processing of causal relations.

1.2 Coherence and knowledge in causal inferences

The coherence of a discourse (representation) results from the semantic relations that interconnect its elements. Of the many types of relations that have been identified (see, for instance, Halliday & Hasan, 1976), the causal relation takes a special place. The concept of causality is basic to human cognition. People try to understand events as consequences of causes and the ability to predict consequences from causes is a fundamental aspect of intelligent behaviour (Noordman & Vonk, 1998). It is not surprising, therefore, to find causal relations to be an important component of the structure of narrative texts, for narratives essentially are descriptions of how events and actions cause changes in the states of objects and persons in the text (Van den Broek, 1994). A similar statement can be made about expository texts (cf. Black, 1985).

The importance of causality has led some theories of reading comprehension, for instance causal chain (e.g., Schank & Abelson, 1977) and causal network theories (e.g., Trabasso, Van den Broek, & Suh, 1989; Van den Broek, 1994), to attribute the coherence of a discourse representation to a great extent to causal relations. Research on the reading of narrative texts has shown that statements that are on the causal chain of events in a narrative or have many causal connections in the text are judged to be more important, are more often included in summary protocols, and are remembered better than statements not in the chain of events or less connected statements. Other studies have shown that causal relations are remembered better than other types of relations (for an overview, see Van den Broek, 1994).

These studies support the claim that causal relations play an important role in reading comprehension. However, they say little about the causal relations themselves. Keenan, Baillet, and Brown (1984) have investigated whether the strength of a causal relation influences the recall of a causally connected sentence (see also Myers, Shinjo, & Duffy, 1987). They presented participants with sentence pairs differing in causal relatedness from strongly related, e.g., *Joey's big brother punched him again and again. The next day his body was covered with bruises.*, to moderately related, e.g., *Racing down the hill, Joey fell off his bike. The next day his body was covered with bruises.*, to weakly related, e.g., *Joey went to a neighbor's house to play. The next day his body was covered with bruises.* For each sentence pair, the event described in the first sentence could be interpreted as the cause for the event in the second. By doing so, the reader would have to make a backward, causal inference. The authors found that the reading times of the second sentences decreased with increasing causal relatedness. The probability of recall of the first sentence, when cued by the second, was shown to be a function of the strength of the causal relation. The probability of recall, however, was highest at intermediate levels of relation strength instead of at the highest level of causal relatedness, which would have been expected. As an explanation, the authors suggested that the pairs with intermediate relations may have evoked more processing in order to construct a meaningful causal relation and consequently may have been more strongly related in memory. This explanation was corroborated by the results of a study reported by Duffy, Shinjo, and Myers (1990). They showed that the differences in recall performance disappeared when readers were asked to explicitly elaborate on the sentence pairs. They suggested that for moderately related sentence pairs, these elaborations are part of the normal comprehension process resulting in a more richly connected memory representation and, therefore, in superior recall. During the processing of strongly related sentence pairs, on the other hand, the causal relations are easily inferred and no elaborations are needed. Memory for these types of sentences is, therefore, poorer. The weakly related sentence pairs, finally, require a relatively large number of elaborations only to obtain a tenuous causal relationship at best. This effort is probably not made during normal reading, and memory for these sentences is poorest.

What Noordman and Vonk (1992) noted about the sentence pairs that were used in the two studies is that the readers had to infer the causal relation between the two sentences in the text on the basis of their own knowledge about them. The causal relations were not signalled by the text. The readers had to construct the discourse-internal (causal) relationship between the events in the text as well as the discourse-external relationship between the events in the text and their world knowledge about them.

Whereas Keenan et al. (1984) and Duffy et al. (1990) studied causal relations that were not signalled by the text but were familiar to the reader, Noordman, Vonk, and Kempff (1992) investigated the reverse situation where the causal relation was signalled in the text but where readers were unfamiliar with the content of the causal relation (see also Vonk & Noordman, 1990; Noordman & Vonk, 1992). They presented participants with expository texts that contained a causal relation that was signalled by the causal connective *because*. For example, in a text on spray cans the causal relation read *Chlorine compounds make good propellants, because they react with almost no other substance*. This relation can be analysed in terms of syllogistic reasoning. What the sentence expresses are the conclusion of the syllogism, *chlorine compounds make good propellants*, and the minor premise, *they* [chlorine compounds] *react with no other substances*. What is missing from the syllogism is the major premise: Propellants must not react with the material in the spray can. The conjunction *because* signals that the information of the major premise has to be inferred in order to justify the causal relation. This inference is backward and contributes to the coherence of the discourse. To test whether knowledge about the causal relation would influence inferential processing, the causal relation was either preceded or not preceded by a sentence explicitly stating the major premise. If an inference is made, this explicitly mentioned premise should facilitate the inference, i.e., the reading of the *because* sentence. The investigators found no evidence for inferential processing during reading, since the reading times did not differ in the explicit and the implicit conditions. The explicit information, however, did help readers to verify the inference sentence after reading the text. Verification times were shorter in the explicit than in the implicit condition, suggesting that the inferences were made during verification.

The study showed that not all causal inferences are drawn during reading. If readers lack the relevant knowledge about a causal relation, they refrain from inferring (discourse-external) information that would enable them to justify the relation. The fact that the causal relations in this study were signalled by a conjunction seems to suggest that readers were satisfied with the (discourse-internal) causal relation as indicated by the text.

The influence of the reader's knowledge on the processing of causal relations has also been investigated in another study where readers either were experts or novices with respect to the causal relations studied (Simons, 1993). Simons investigated the processing of causal relations in the knowledge domain of economics. The knowledge structures of economic experts (graduate students of economics) and novices (graduate students in other, unrelated disciplines) were determined and concepts were identified that were causally related for the experts but not for the novices. Causal sentences were constructed that were based on triplets of causally related economic concepts. For instance, *exports*, *inflation*, and *competitive position* would combine into the following causal sentence: *American exports have been suffering a decline, because rising inflation has produced a harmful effect on the competitive position of the U.S.A.* From this sentence it could be inferred that *deterioration of competitive position leads to a decline in the exports*. The sentences were presented in two conditions: with or without preceding statements priming the inferential information. For this example, the explicit sentence read *Generally speaking, the competitive position of a country has a strong influence on the volume of its exports.* The reading time results showed a facilitative influence of the presence of explicit information for economic experts only, indicating that experts made the inference during the reading of the causal sentence. No such facilitation was found for the novices. Apparently, they did not make the inference during reading. The causal relation was inferred by novices, however, when this was required by a verification task after the reading of the text.

The results of Simons' (1993) study are in line with those of Noordman et al. (1992). Both studies show that if readers are unfamiliar with the content of a causal relation, they will not spontaneously make a backward causal inference. If they are knowledgeable about the causal relation, they do make the inference on-line (Simons, 1993). Put differently, inferences that are derivations of new knowledge are not made spontaneously during reading, whereas inferences that are activations of available knowledge are. This conclusion and the studies on which it is based raise two questions, however. They will be addressed in the present study. The first question pertains to the role of the reader's knowledge and the second to the role of linguistic signalling.

1.3 Scope of the thesis

The first question raised by the conclusion of the studies on causal inferencing mentioned above is related to the reader's knowledge. The results of these studies are based on the investigation of very specific causal relations that either were very well known to the reader or not known at all. It is an open question what happens in between these extremes. What if the causal relation is not very specific to a knowledge domain but belongs to the realm of general world knowledge where the reader's knowledge can be seen as graded on the scale of knowledgeability? Does the dichotomy between having knowledge and not having knowledge apply to relations about which readers are more or less knowledgeable? The second question pertains to the use of the connective *because* in the causal relation sentences in the two studies. The finding that inferences are made if the reader is well acquainted with the causal relation was contaminated with the presence of this causal connective: In all but one experiment the causal relations were signalled by the connective *because*. As a result of the presence of the connective, the inferences are necessarily true implications of the text. It is unclear what happens if the reader is very well acquainted with the causal relation but the relation is not indicated by a conventional implicature. Only one experiment by Simons (1993, Exp. 8) sheds some light on this matter. Simons obtained evidence for on-line inferential processing in the absence of a causal connective for knowledgeable readers only.[1] This suggests that the presence of the causal connective need not have any influence. However, it leaves open the question whether a similar conclusion can be drawn with respect to causal relations in the domain of general world knowledge instead of causal relations in highly specific knowledge domains.

The present study seeks answers to these questions by presenting readers with more or less familiar causal relations belonging to everyday knowledge that are or are not signalled by the causal connective *because*. The causal relations are based on enthymemes, syllogistic reasonings with a missing premise (cf. Noordman et al., 1992; Vonk & Noordman, 1990; Singer, Halldorson, Lear, & Andrusiak, 1992). An example is given in Table 1.1. The causal inference consists of the missing major premise.

Table 1.1: Example of the syllogistic chain of reasoning underlying a textual causal relation. The major premise has to be inferred.

Causal relation:	
On his way to work, mister Smith was delayed, because there was a traffic jam on the highway.	
Syllogism:	
Major premise:	*A traffic jam causes delay*
Minor premise:	*Mister Smith was in a traffic jam*
Conclusion:	*Mister Smith was delayed*

Two stances can be taken regarding the role of the reader's knowledge with respect to the inferring of causal relations. If one assumes that high and low degrees of familiarity in the domain of general world knowledge are similar to the distinction between 'expert' and 'novice' knowledge, one would have to predict that inferences will only be made if readers are very familiar with the causal relations, but not if they are not very familiar with them. If one sees familiarity levels as gradations of 'expert' knowledge, inferences are hypothesised to occur in either familiarity condition.

[1]This result was based on probe recognition times during reading and not on reading times or verification times as in the other experiments. A direct comparison of this result and those of the other experiments, therefore, was not possible.

As to the influence of the causal connective, it is an empirical question whether the conventional implicature is a prerequisite for causal inferencing to take place during normal reading. One might think that its influence depends on the degree of familiarity of the causal relation.

The next chapter deals with defining the familiarity of causal relations in the domain of general world knowledge (Chapter 2). Chapters 3 and 4 report the psycholinguistic experiments that investigate the influence of familiarity with the causal relation and the presence of the causal connective on the on-line processing of causal relations. Chapter 5 deals with some methodological issues related to the use of the eye-movement recording technique as exploited in Experiment 6, Chapter 4. In the final chapter, the results are summarised and their implications are discussed.

CHAPTER 2

Construction of materials

2.1 Introduction

As stated in the previous chapter, the reader's knowledge plays an important role in inferring causal relations during reading. This has been shown in an expert-novice paradigm (Simons, 1993) and with texts about unfamiliar topics (Noordman et al., 1992). It was found that knowledgeable readers infer a causal relation given by a conventional implicature, whereas readers who are considered to be novices with respect to the subject of the text do not make this inference. In other words, it seems that inferences that are activations of available knowledge are made spontaneously during reading (Noordman & Vonk, 1992).

These studies investigated the role of the reader's knowledge on inferential processing by comparing readers who either were knowledgeable about the content of the causal relation or were unfamiliar with it (Noordman & Vonk, 1992; Simons, 1993). Causal relations were selected that belonged to very specific knowledge domains, e.g., economics, and readers were either 'experts' with respect to that knowledge domain or 'novices.' The current study extends the investigation of the influence of reader's knowledge on inferential processing to possible or necessary causal relations in the domain of general world knowledge. The influence of the reader's knowledge is not investigated by comparing the behaviour of different types of readers (experts versus novices) on the same causal relations but by comparing the behaviour of the same readers on different types of causal relations (familiar versus not very familiar causal relations).

When one investigates the role of the reader's knowledge on the processing of causal relations in the domain of general world knowledge, an obvious problem is how to determine which causal relations are and which ones are not very well known to the reader. There is no easy way to establish this. Familiarity is not an intrinsic feature of causal relations that can be measured directly. The current study, therefore, employs an empirical method to select causal relations that either are or are not very well known to the reader.

In the domain of general world knowledge, everybody is considered to be knowledgeable, at least, to a certain extent. Events, states, and the relationships between them, in this domain can be considered very familiar if one can assume that (almost) everybody knows them. This knowledge comes about directly as a result of personal experience but also indirectly as a result of learning. Not everybody needs to have experienced a delay as a result of a traffic jam to know that traffic jams cause people to be late. People learn about traffic jams and their consequences because, in everyday life, they occur often, are talked about at home, at school, and at work, are discussed extensively on the radio and on television, and are written about in newspapers and magazines. Given this state of affairs, when presented with the information that someone who travels by car is late for work, one immediately thinks of a traffic jam as a plausible cause. In fact, in the absence of other information, most will consider it to be the most plausible cause. Finding very familiar causal relations in the domain of everyday knowledge, therefore, is tantamount to finding what most people believe to be the most plausible cause for a well-known event or state.

The two experiments reported here made use of the judgement of plausibility of a cause by participants to determine whether a causal relation in the domain of everyday knowledge is very familiar. In the first experiment, participants were asked to complete the last sentences of short texts by supplying the most plausible cause for an event or state described in the text. In the second experiment, the results of the first experiment were validated with a plausibility judgement task.

Table 2.1: Example of a text containing a causal relation as conceived prior to Experiment 1, containing two versions of the causal relation, one with a very plausible cause and one with a not very plausible cause (English translation below).

Version with a very plausible cause
De heer Smit verliet rond half acht het huis.
Hij moest op zijn werk een belangrijke vergadering voorzitten.
Daarom was hij van plan om die morgen de papieren goed door te nemen.
Hij haalde zijn auto uit de garage en reed weg.
Op weg naar het werk had hij die ochtend vertraging,
omdat er op de snelweg een lange file was ontstaan.
Hij was blij dat hij wat eerder was vertrokken.
Hij hield er niet van om te laat te komen.

Version with a not very plausible cause
De heer Smit verliet rond half acht het huis.
Hij moest op zijn werk een belangrijke vergadering voorzitten.
Daarom was hij van plan om die morgen de papieren goed door te nemen.
Hij haalde zijn auto uit de garage en reed weg.
Op weg naar het werk had hij die ochtend vertraging,
omdat er op de snelweg politiebewaking was.
Hij was blij dat hij wat eerder was vertrokken.
Hij hield er niet van om te laat te komen.

English translation:
Version with a very plausible cause
Mister Smith left his house at eight o'clock. At work, he had to chair an important board meeting. That is why he had planned to study the papers thoroughly. He fetched his car from the garage and drove off. On his way to work that morning he was delayed, *because there was a traffic jam on the highway.* He was glad that he had left earlier. He hated to be late.
Version with a not very plausible cause
Mister Smith left his house at eight o'clock. At work, he had to chair an important board meeting. That is why he had planned to study the papers thoroughly. He fetched his car from the garage and drove off. On his way to work that morning he was delayed, *because there were police patrols on the highway.* He was glad that he had left earlier. He hated to be late.

2.2 Experiment 1

Initially, 30 texts on everyday topics were constructed which were meant to contain a causal relation in two versions: with a very plausible cause and with a less plausible cause (for a textual example, see Table 2.1).

The texts conformed to the following structure: four introductory sentences, a target sentence with a causal relation, and two concluding sentences.[1] The four introductory sentences had to introduce the situation in which the event described in the causal relation could occur. The causal relations consisted of a consequence-cause sequence designed according to the principles of a syllogistic chain of reasoning (see Table 1.1). For example, in the sentence *On his way to work mister Smith was delayed, because there was a traffic jam on the highway.*, the first part (the consequence) conveys the conclusion, *Mister Smith was delayed*, and the second part (the cause) the minor premise, *Mister Smith was in a traffic jam*. The major premise, *A traffic jam causes delay*, was not given in the text but can be inferred in order to justify the relation. The causal consequences were chosen so as to have one very plausible cause and one or more not very plausible causes. Each text was concluded with two sentences that formed a natural ending to the text.

In order to validate the causes that were originally conceived, the texts were presented in the first experiment up to and including the connective *because*, and participants were asked to complete the *because*-sentence with what they believed to be the most plausible cause for the event described in the text. It was expected that most participants would supply the same causes that were originally created for the very plausible versions.

2.2.1 Method

Participants

Forty-nine students, 29 women and 20 men ranging in age from 19 to 29, from the University of Nijmegen were paid to participate.

Materials

The 30 texts on everyday topics that had been constructed by the experimenter were presented up to and including the causal connective of the causal relation. The texts consisted of four sentences and a clause. The

[1] The texts and the causal relations were produced by the author and were discussed with colleagues.

first four sentences constituted a short story that led up to an event or a state described in the final clause. The final clause, which was the first part of a causal relation, ended with a comma and the connective *because* (see Table 2.2 for an example). Every participant in the experiment received the thirty texts in the same order.

Table 2.2: Example of an experimental text in Experiment 1 (English translation below).

De heer Smit verliet rond half acht het huis.
Hij moest op zijn werk een belangrijke vergadering voorzitten.
Daarom was hij van plan om die morgen de papieren goed door te nemen.
Hij haalde zijn auto uit de garage en reed weg.
Op weg naar het werk had hij die ochtend vertraging,
omdat . . . .

English translation:
Mister Smith left his house at eight o'clock. At work, he had to chair an important board meeting. That is why he had planned to study the papers thoroughly. He fetched his car from the garage and drove off. On his way to work that morning he was delayed, because. . . . .

Procedure

Texts were presented on a computer display in a self-paced moving-window fashion. The unit of presentation in the moving window was one line of text containing either a clause or a complete sentence. Each text was preceded by a warning signal consisting of the words 'NEW TEXT', which stayed on the screen for one second and was followed by an asterisk. When ready to start reading, the participant pressed a button and the first line of text appeared, replacing the asterisk. After reading this sentence, the button was pressed again and the next sentence appeared below the first, which at the same time disappeared. This procedure continued until a line appeared that started with the connective *because* and was followed by a string of dots. At that moment, the participants had to say out loud what they believed to be the most obvious cause for the event or situation described in the text. The response was recorded on a recording device and was written down by the experimenter. After the response, the next button press cleared the screen, making way for the warning signal 'NEW TEXT.'

Participants were instructed to read the texts carefully so as to understand them and to be able to complete the *because*-sentence properly. They were urged to respond quickly and to mention the most obvious cause that came into their mind. The experiment started with a trial text in which the participants could get acquainted with the task.

2.2.2 Results and discussion

Quantitative analysis. The responses of the 49 participants to the 30 texts were rated by two independent judges. There were 2 responses missing. The judges compared the responses given by the participants to the originally conceived plausible causes using three nominal categories: identical, paraphrase, and non-identical. Identical meant that the participant's response contained the same words as the originally conceived continuation or close-synonyms and that the utterance expressed the same underlying cause; a response was considered a paraphrase if it contained other words to convey the same message as the original; and a response was non-identical if it expressed a completely different cause. For example, one of the text fragments described a couple that was shown a house that they might be interested in buying. The fragment ended with the sentence *They decided not to buy it, because....* The originally conceived cause for this event was that the house was too expensive. If a participant responded with *because it was very expensive*, the completion was rated as identical; if the response was *because they didn't have enough money*, it was rated as a paraphrase; and if the participant's response read *because it was too big*, it was rated as non-identical. The interrater agreement on the three categories as measured by Cohen's Kappa (Cohen, 1960) was substantial: $\kappa = 0.77$ ($p < 0.01$). Table 2.3 shows that judges differed slightly with respect to their interpretation of the category identical. One judge was more lenient and considered some utterances as identical, whereas the second judge considered these sentences paraphrases.

The table also shows that in 72% of the cases (524 + 176 + 15 + 339) a response was produced that was judged to be identical to, or a paraphrased version of, the originally conceived plausible cause. In 28% of the cases, another cause was given.

Table 2.3: Interrater agreement for responses in texts with a very plausible cause between two judges on three categories: identical, paraphrase, and non-identical (Experiment 1).

	judge A			
judge B	identical	para-phrase	non-identical	$\sum$
identical	524	176	0	700
paraphrase	15	339	1	355
non-identical	1	24	388	413
$\sum$	540	539	389	1468

Qualitative analysis. On the basis of the analysis of the responses per text, the texts were divided into three groups. The first group consisted of 18 texts that elicited the originally conceived cause (identical or paraphrase) in 70% or more of the cases. The alternative causes that were produced with these texts were never mentioned by more than 15% of the participants. The second group consisted of six texts in which the originally conceived cause (identical or paraphrase) was only mentioned by 37% to 70% of the participants. These texts were responded to with alternative causes, but the number of occurrences of the alternatives never exceeded that of the originally conceived causes. The last group of texts consisted of six texts that generated an alternative cause as the most plausible cause for the event in the text. These alternative causes were produced, on average, in 39% of the cases compared to 27% for the originally conceived plausible causes.

No improvements, apart from minor changes to the wording of the texts, were deemed necessary for the texts of the first group. These texts elicited the same causes as those originally conceived and did not produce strong alternative causes. They confirmed the expectation that the originally conceived causes were the most plausible causes for the consequences given in the text. The texts from the second group that elicited strong alternatives to the expected primary cause and the texts from the third group that produced an alternative cause as the primary response were changed.

Examination of the second group of texts, which elicited the originally conceived causes as the primary response, revealed that the strong alternatives were brought about by particular parts of the text. By altering these parts, the texts were improved so as to make the alternatives less plausible and, consequently, the original cause more plausible. For instance, in one of the texts, a couple was introduced that decided not to buy a particular house in a big town. The originally conceived cause was that the house was too expensive. This indeed was found to be the main response. However, a lot of participants mentioned that the neighbourhood was too noisy. This alternative was easily dealt with by situating the house in a quiet street, thereby excluding noise as an alternative.

The texts of the third group, which were completed by the participants with another cause than the originally conceived one, were altered either to create a better context for the originally conceived cause (five texts) or to create a proper context for the main alternative cause that the participants had provided (one text).

The responses of the participants were also used to verify the less plausible versions of the originally conceived causes. It was assumed that, if at all, these causes would not be given by many participants. For 21 texts, less than 15% of the participants mentioned the originally conceived less plausible cause. These causes were maintained. The originally conceived less plausible causes of the remaining texts were not reproduced once by the participants. They formulated other causes that were equally infrequent (less than 15%). In order to decide which of these causes to use as the less plausible version in the reading experiments, they were submitted to the plausibility judgement task in Experiment 2 (see below).

To summarise, the first experiment resulted in the improvement of 30 texts that contained a causal construction in two versions, one with a very plausible cause and one with a less plausible cause. In 24 texts, the improvements consisted of minor changes, and in six texts the changes were more substantial. The plausibility of the causes for the causal constructions embedded in the (improved) texts were further tested in Experiment 2.

2.3 Experiment 2

The second experiment was set up to test the plausibility of the causes more directly by using a plausibility judgement task. The improved texts of the first experiment were presented to the participants up to and including the first clause of the causal construction (the consequence of the causal relation). The causal connective *because* was not included and the sentence ended with a period. The causes that resulted from the first experiment were presented as continuing sentences of the text and participants were asked to judge their plausibility on a scale ranging from *very plausible* to *no reason or cause* (see Table 2.4).

Table 2.4: Example of an experimental text and the five types of causal clauses in Experiment 2 (the plausibility judgements have been filled out in the example for the purpose of illustration).

Mister Smith left his house at eight o'clock.
At work, he had to chair an important board meeting.
That is why he had planned to study the papers thoroughly.
He fetched his car from the garage and drove off.
On his way to work that morning he was delayed.

	reason or cause			
	no reason	implausible	not very plausible	very plausible
(a) There was a traffic jam on the highway.				x
(b) There were police patrols on the highway.			x	
(c) There was a thick fog on the highway.			x	
(d) He had forgotten to take his papers.		x		
(e) Fortunately, there was a nice program on the radio.	x			

Note: The ordering of the five clauses in this example is for presentation purposes only: (a) contains a very plausible cause, (b) a not very plausible cause, (c) an alternative not very plausible cause, (d) an implausible cause, (e) a non-causal, temporal continuation.

It was expected that the plausibility scores of the participants would corroborate the findings of the first experiment. Furthermore, the experiment offered an opportunity to test the plausibility of several less plausible causes per text. For some texts, the participants of Experiment 2 did not reproduce the originally conceived less plausible causes but, instead, other causes. These alternative causes could also be labelled not very plausible, because they were mentioned only a few times (by less than 15% of the participants). Both these causes and, of course, the very plausible causes were entered into the second experiment, making a direct comparison of their plausibility on the plausibility possible.

2.3.1 Method

Participants

Twenty-six students, 15 women and 11 men ranging in age from 18 to 27, from the University of Nijmegen were paid to participate.

Materials

The 30 texts from the first experiment were used. As explained above, each text was presented up to and including the first clause of the causal construction. This first clause ended with a period. Below the text, five types of clauses were presented (see the example in Table 2.4). Three clause types were obtained from Experiment 1. The first type consisted of a clause that contained a very plausible cause for the situation or event described in the first clause of the causal construction; the second clause type expressed the originally conceived less plausible cause; and the third type consisted of a clause with an alternative less plausible cause, one that had been generated by the participants in Experiment 1. These three clause types were supplemented with two other types of clauses that were added to supply the judgement task with the necessary differentiating power: a clause that expressed an implausible cause, and a clause that contained no cause at all but constituted a non-causal, temporal continuation of the text.[2] The five types were labelled as follows: (a) *very plausible*, (b) *not very plausible*, (c) *alternative not very plausible*, (d) *implausible*, and (e) *non-causal, temporal*.

Not all texts were presented with an implausible version of the clause. This was the case if the first experiment yielded several alternatives to the

[2] The implausible and the non-causal, temporal versions were created in a similar way as the original texts.

not very plausible cause that were considered equally less plausible. For those texts, the implausible version was replaced by one of these alternative not very plausible causes. This was the case for 6 items.

The ordering of the texts was the same as in the first experiment. The texts were presented on five lists, each with a different semi-random ordering of the five types of clauses. Each participant saw only one list.

Procedure

Participants were assigned to groups of 5 to 10 in a paper-and-pencil experiment. The experimental materials consisted of 30 texts, divided over 10 pages with 3 texts on each page. The participants were (verbally) instructed to read each text carefully so as to understand it. After reading the text, they had to judge on a four-point scale how plausible a reason or cause each of the five clauses was as cause for the situation or event described in the text. They were explicitly told that they should judge each sentence separately and independently. The judgements they could give were: *very plausible reason or cause*, *not very plausible reason or cause*, *implausible reason or cause*, and *no reason or cause*. These categories were explained as follows: If the participant thought that the continuing sentence expressed what most people would believe to be the cause for the situation or the event described in the text, then they should put a mark at *very plausible* behind the sentence; if they believed that what the sentence referred to was possible but not very plausible, then they should mark *not very plausible*; if they found the continuation rather far-fetched, they should mark *implausible*; and if they thought that the continuation was not a reason at all, they should check *no reason*. These categories were clarified with a written example that was handed out during the instruction. It contained a text fragment with the five possible continuations already marked. It took participants approximately 45 minutes to complete the experiment.

2.3.2 Results and discussion

The judgements were scored as follows: *no reason or cause* a 1; *implausible* a 2; *not very plausible* a 3; and *very plausible* a 4. For each of the 26 participants, 150 judgements were collected (30 texts times 5 clauses), resulting in 3900 judgements. There were 2 missing cases.

The five types of clauses were compared separately in two analyses of variance, one with participants as random variable (F1) and one with items as random variable (F2). In both analyses, Clause type was treated as a within factor. The ordering of the clauses in five lists was a between participants factor. The mean judgement values are given in Table 2.5. Note that the mean of the *implausible* clauses was based on 24 clauses and the mean of the *alternative not very plausible* clauses on 36 clauses.

Table 2.5: Mean plausibility judgement values and standard deviations of the five clause types on a four-point scale, ranging from 1 *no reason or cause* to 4 *very plausible reason or cause* (Experiment 2).

clause types[a]	*M*	*SD*
(a) There was a traffic jam on the highway.	3.85	0.019
(b) There were police patrols on the highway.	2.96	0.055
(c) There was a thick fog on the highway.	2.60	0.044
(d) He had forgotten to take his papers.	2.19	0.072
(e) Fortunately, there was a nice program on the radio.	1.29	0.040

[a] (a) very plausible, (b) not very plausible, (c) alternative not very plausible, (d) implausible, (e) non-causal, temporal

All means differed significantly from one another. The planned comparison between the mean plausibility judgements of the *very plausible* and the *not very plausible* clauses revealed a very significant difference: $F_1(1,21) = 299.19$, $MSE = 0.03276$, p < 0.001; $F_2(1,29) = 84.69$, $MSE = 0.09024$, $p < 0.001$. Similar results were obtained for the analyses of the *not very plausible* clauses and the *alternative not very plausible* clauses: $F_1(1,21) = 81.49$, $MSE = 0.0204$, p < 0.001; $F_2(1,29) = 9.97$, $MSE = 0.230$, $p < 0.01$, the *alternative not very plausible* clauses and the *implausible* clauses: $F_1(1,21) = 162.51$, $MSE = 0.01281$, $p < 0.001$; $F_2(1,29) = 4.85$, $MSE = 0.273$, $p < 0.05$, and the *implausible* clauses and the *non-causal, temporal* clauses: $F_1(1,21) = 99.50$, $MSE = 0.105$, $p < 0.001$; $F_2(1,23) = 106.80$, $MSE = 0.09239$, $p < 0.001$.

The means for the five types of clauses were significantly different and were in line with what could be expected on the basis of the judgement scale: The mean of the *very plausible* clauses lay close to scale value 4 (very plausible), the mean of the *non-causal, temporal* clauses was near scale value 1 (no reason or cause), and the means of the other clauses fell in between. This shows that the plausibility judgement scale was able to differentiate between the different types of clauses.

The difference between the plausibility judgements of the clauses containing *very plausible* causes and those containing *not very plausible* causes supported the results of Experiment 1. The clauses expressing the *very plausible* causes as obtained in Experiment 1 were rated as significantly more plausible than those with the *not very plausible* causes in the first experiment.

The results of the second experiment were used to screen the very plausible and the not very plausible clauses. When averaged over participants, the mean judgement scores of the clauses of a text differed. The deviation from the expected score of the clauses on the plausibility scale was used to select the best among them. The size of the allowed deviations was determined by defining non-overlapping ranges within which the mean judgement score of a particular clause should fall. The ranges were set as follows: If the mean judgement score of a very plausible clause fell between 3.5 and 4, it was considered *very plausible*; if it fell below this range, it was excluded. Analogously, if the mean judgement value of a not very plausible clause (note that this included the set of alternative not very plausible clauses as well) fell between 2.5 and 3.25, it was considered *not very plausible*; otherwise it was excluded.

Table 2.6: Mean plausibility judgement values and standard deviations of the selected very plausible and not very plausible clauses on a four-point scale, ranging from 1 *no reason or cause* to 4 *very familiar reason or cause* (Experiment 2).

very plausible		not very plausible	
M	*SD*	*M*	*SD*
3.90	0.016	2.63	0.055

This procedure resulted in 24 texts with two versions of the second clause of the causal construction: a clause expressing a very plausible cause and a clause expressing a not very plausible cause. Analyses of variance of the mean judgement values of these two clause types (see Table 2.6) showed that the *very plausible* and the *not very plausible* causes which were selected on the basis of non-overlapping scoring values differed significantly on a plausibility scale: $F_1(1,21) = 574.34$, $MSE = 0.03480$, $p < 0.001$; $F_2(1,23) = 286.19$, $MSE = 0.06685$, $p < 0.001$.

2.4 Conclusion

As mentioned before, there is no way to determine on purely theoretical grounds whether a causal relation is familiar. The familiarity of causal relations was therefore established empirically.

The two experiments reported here used a causal completion task and a plausibility judgement task to find causes in the domain of everyday knowledge that either are very plausible or not very plausible. Causes that were produced by many participants in order to explain an event or state described in the final sentence of the text were systematically judged by other participants to be very plausible. Conversely, causes that were produced incidentally in the causal completion experiment were rated independently as being not very plausible. It is assumed that the plausibility of a cause for a given consequence indicates the familiarity of their relationship. In this sense, the two experiments on the plausibility of causes for everyday events have resulted in texts containing causal relations that either are very familiar or not very familiar to the readers.

The two experiments resulted in 24 experimental texts (see Appendix B) on everyday topics with a very familiar version of the causal relation and with a not very familiar version. These texts were used in the reading experiments described in Chapters 3 and 4.

CHAPTER 3

Inferring causal relations

3.1 Introduction

As explained in the first chapter, previous research has demonstrated that readers who are knowledgeable about the content of a causal relation use that knowledge during reading to make a backward, bridging inference. These findings were obtained in an expert-novice paradigm in which knowledge was manipulated between readers (Simons, 1993). When participants were unfamiliar with the causal relations, they only made an inference if the reading task invited them to do so (Noordman et al., 1992). These findings support the claim that only inferences that are activations of available knowledge are made spontaneously during reading (Noordman & Vonk, 1992).

The present study extends this research by investigating the inferential processing of causal relations in the domain of general world knowledge. The influence of the reader's knowledge is studied by manipulating the familiarity to the reader of these causal relations. The reader's knowledge about a very familiar causal relation is assumed to be highly available, whereas the availability of the reader's knowledge about a less familiar causal relation is substantially lower.

In the light of the studies mentioned above, two models can be formulated with respect to the manipulation of the familiarity of the causal relations in this domain. The two levels of familiarity can be seen as representing 'expert' and 'novice' knowledge, or they can be viewed as reflecting two levels of 'expert' knowledge. These models lead to different predictions about inferential processing. According to the model that looks upon the distinction between high and low familiarity as an expert-novice distinction, it can be expected that if the relation is very familiar, the causal relation will be processed and the causal inference will be made. If the reader is not very familiar with the relation, the causality will be taken for granted and the causal inference will not be made. On the other hand, if one assumes that the familiarity distinction reflects two levels of 'expert' knowledge, it is expected that inferences are made in both familiarity conditions.

Another issue brought forth by the above-mentioned studies pertains to the role of the connective *because* in the inferential processing of causal relations. In these studies, the causal relations were linguistically signalled by the causal connective *because*. Although this device by itself justifies the making of an inference, it apparently is not compelling enough to elicit an inference, nor does it seem to be a necessary condition for making one. The results of the studies are not conclusive. On the one hand, the presence of the connective by itself is not sufficient to elicit a causal inference, as was evidenced by the results of readers who had no knowledge whatsoever about the causal relation. They did not make an inference even if the connective was present (Noordman et al., 1992; Simons, 1993). On the other hand, readers who had 'expert' knowledge about the content of the causal relation did make an inference even in its absence (Simons, 1993). What is the role of the connective? Is all that matters the knowledge the reader has about the causal relation?

A direct conclusion about the influence of the connective *because* on inferential processing based on previous studies is not possible because the presence of the connective was not manipulated experimentally in any of these studies. Within each experiment, the connective was either present or absent. The goal of the present study is to investigate the role of the connective more systematically.

The expectations about the influence of the connective *because* on the making of an inference depend on the assumptions about the role of the familiarity of the causal relation. If the distinction between very familiar and not very familiar causal relations is similar to the distinction between experts and novices, one expects the presence of the connective to be of no consequence. Inferences will be made if the readers are very familiar with the causal relation and not made if they are not.

Table 3.1: Predictions about the making of a causal inference dependent on the role of the Familiarity of the causal relation and the presence of the causal Connective *because* according to the two models of the reader's knowledge.[a]

	expert-novice knowledge		two levels of 'expert' knowledge	
	Connective		Connective	
Familiarity	present	absent	present	absent
very familiar	+	+	+	+
not very familiar	-	-	+	-

[a] A plus-sign signals that the inference is expected to be made and a minus-sign that the inference is expected not to be made.

If the distinction between more and less familiar causal relations reflects two levels of 'expert' knowledge, the connective will not be expected to make a difference with respect to the processing of very familiar causal relations. Knowledge about very familiar causal relations is readily available and it will take relatively little effort to infer the implicit information even in the absence of a causal connective. If, however, the relations are not very familiar, it might be the case that the connective does play a role. The reader's knowledge of the relation is less available and it would take a greater effort to bring this knowledge to the fore. The causal connective might just be the trigger to activate this knowledge and elicit the inference (see Table 3.1 for a schematic view of the models' predictions).

3.2 Experiment 3

In this experiment, reading times, probe recognition times, and verification times were used to investigate whether, during the processing of the causal relations, causal inferring has taken place. The measurement of reading times is an on-line technique: It reflects processes occurring during reading. Since inferential processes are assumed to take up time, they are expected to show up in the reading times. If, during the processing of the causal construction, a causal inference is made, the reading time of the second clause of the construction will be longer than if no inference is made.

The second on-line technique used is the measurement of the availability of information by means of a probe recognition task. The text presentation is interrupted and a single word appears on the screen. The reader has to decide as fast as possible whether that word has occurred in the text. The technique is based on the assumption that, during reading, incoming information is temporarily stored and processed in working memory and that concepts that are in working memory are highly active. The probe recognition times reflect the availability, or the activation level, of the probe word in memory (McKoon & Ratcliff, 1980). The task can be used to detect the making of an inference. Take for example the causal relation *He wasn't able to drive home that night, because he had been drinking a lot.* If the inference *if you have drunk a lot, you're not able to drive* is made in order to understand the causal relation, it is assumed that both clauses of the causal relation are in working memory. Consequently, the activation levels of the words contained in the clauses will be high and their recognition will be easy. It is expected, therefore, that if the inference is made, the recognition of the word *night* will be faster than if the inference is not made.

The third technique, the registration of verification times, is an off-line technique to measure the occurrence of an inference. It is an off-line method, since it measures the effects of cognitive processing indirectly by assessing its product after reading. The verification sentence consists of the inferential information. It is assumed that it will take relatively little time to judge whether the verification sentence is true with respect to the text if the reader has made the inference during reading. If, however, the causal inference has not been made during reading, the verification judgement will be more time-consuming, since the inference will have to be made at test time.

The three measures allow for a comparison of the two different models about the reader's knowledge. According to the model that regards the very familiar and less familiar conditions as the distinction between knowledge of experts and knowledge of novices, as in Simons (1993), inferences should be made if the causal relation is very familiar but not if it is not. This should show as a main effect of familiarity on the probe recognition task: Probes should be recognised faster in the very familiar condition than in the not very familiar condition, and there should be no interaction with the presence of the connective. Regarding the verification times and the reading times, the expectations were not so straightforward. Since the comparison of familiarity conditions for these tasks entailed a comparison of different sentences, it might be that even if no inference was made, a difference would show up in the verification times and the reading times. This difference might be attributed to the ease of processing sentences containing very familiar information compared to sentences containing less familiar information. As to the verification times, the ease of processing a very familiar verification sentence might add up to the effect attributable to the making of an inference. If an inference is made, the verification times should be shorter in the very familiar than in the less familiar condition, and this difference might increase due to the ease of processing verification sentences in this condition. The reading times, on the other hand, might show a cancellation of these effects. Since inferences take up time, it would be expected that the reading times would be longer in the very familiar condition compared to the less familiar condition. However, this difference might be weakened as a result of the greater ease with which very familiar sentences are processed. Although no predictions could be made with respect to an effect of the familiarity of the causal relation for the verification times and the reading times, the model does predict that there should be no interaction between the familiarity of the causal relation and the presence of the connective *because*, for the connective should have no effect on the making of an inference. If the relation is very familiar, the inference should be made independently of the presence of the connective, and if the relation is not very familiar, no inference would be expected, again independently of the presence of the connective.

The assumption that the familiarity distinction reflects two levels of expert knowledge allows for a different prediction. According to this model, inferences are made irrespective of the familiarity of the causal relation.

Therefore, there should be no main effect of familiarity on the probe recognition task. As to the role of the connective, it is hypothesised that the familiarity of the causal relation and the presence of the connective interact. If the causal relation is very familiar, the presence of the connective should have no effect on the inferential process. If the causal relation is not very familiar, however, the presence of the connective might just be the trigger to elicit the inference. Therefore, an interaction between familiarity and presence of the connective was expected for the probe recognition times, the verification times, and the reading times. The probe recognition times and the verification times should be shorter and the reading times should be longer if the connective is present.

A schematic presentation of the expectations for the three measures according to the two models is given in Table 3.2.

Table 3.2: Schematic presentation of the expectations regarding the effects of Familiarity of the causal relation and the presence of the Connective on the probe recognition times, the verification times, and the reading times in Experiment 3 according to the two models about the familiarity of reader's knowledge.[a]

measure	model: 'expert'-'novice' knowledge	model: two levels of 'expert' knowledge
probe recognition times	no interaction RT_{fam} x RT_{conn}: $\mathrm{RT}_{vf} < \mathrm{RT}_{nvf}$ $\mathrm{RT}_{conn-pres} = \mathrm{RT}_{conn-abs}$	interaction RT_{fam} x RT_{conn}: $\mathrm{RT}_{vf,conn-pres} = \mathrm{RT}_{vf,conn-abs}$ $\mathrm{RT}_{nvf,conn-pres} < \mathrm{RT}_{nvf,conn-abs}$
verification times	no interaction RT_{fam} x RT_{conn}: $\mathrm{RT}_{conn-pres} = \mathrm{RT}_{conn-abs}$	interaction RT_{fam} x RT_{conn}: $\mathrm{RT}_{vf,conn-pres} = \mathrm{RT}_{vf,conn-abs}$ $\mathrm{RT}_{nvf,conn-pres} < \mathrm{RT}_{nvf,conn-abs}$
reading times	no interaction RT_{fam} x RT_{conn}: $\mathrm{RT}_{conn-pres} = \mathrm{RT}_{conn-abs}$	interaction RT_{fam} x RT_{conn}: $\mathrm{RT}_{vf,conn-pres} = \mathrm{RT}_{vf,conn-abs}$ $\mathrm{RT}_{nvf,conn-pres} > \mathrm{RT}_{nvf,conn-abs}$

[a] Abbreviations and symbols: **fam**: Familiarity; **conn**: Connective; **conn-pres**: connective present; **conn-abs**: connective absent; **vf**: very familiar; **nvf**: not very familiar; **equal-sign**: not different from; **less-than-sign**: is smaller than; **more-than-sign**: is larger than

3.2.1 Method

Participants

Forty-one students from Tilburg University were paid to participate, 22 women and 19 men, ranging in age from 18 to 27. The results of 32 participants were entered into the analyses.

Materials

The 24 texts that were used resulted from the materials construction experiments reported in Chapter 2. The texts contained a causal relation that was constructed according to a syllogistic chain of reasoning as explained in Chapter 1 (see Table 1.1). A text was presented to a participant in one of four conditions (see Table 3.3). Therefore, there were four lists. The ordering of the 24 texts in each of these lists was the same. A list contained six texts in each condition. The average length of the second clauses (without connective) of the causal constructions was 39.4 characters (*SD* 6.2) or 10.5 syllables (*SD* 1.7) in the very familiar condition and 39.4 characters (*SD* 4.8) or 10.6 syllables (*SD* 1.7) in the not very familiar condition.

The first part of every causal construction contained a target word to be presented as a recognition probe. The selected words were all nouns and semantically non-central to the meaning of the text. Care was taken that the probe words were first occurrences: They had not been used in the texts preceding them. The probe words varied in length from 3 to 9 characters (*M* 5.25, *SD* 1.7). Each text was followed by a verification sentence consisting of the inferential information, that is, the major premise of the syllogistic chain of reasoning underlying the causal relation.

In addition to the 24 experimental texts, 48 filler texts were included. These texts resembled the experimental texts in topics and style, but did not contain causal constructions or the word *because*, the connectives being, for example, *but, while, after, when*. The length of the filler texts ranged from 6 to 11 clauses. The position of the probe recognition targets was varied from clause 2 to clause 10, thus preventing readers from anticipating its occurrence. Without the filler texts, it would be easy to predict the exact moment of presentation of a probe recognition target, since in the experimental texts all probe words appeared after the sixth sentence, the

Table 3.3: The four conditions of an experimental text in Experiment 3: a very familiar (vf) causal relation with *because*, a very familiar causal relation without *because*, a not very familiar (nvf) causal relation with *because*, and a not very familiar causal relation without *because* (probe word underlined, target clause in italics, English translation below).

	De heer Smit verliet rond half acht het huis.
	Hij moest op zijn werk een belangrijke vergadering voorzitten.
	Daarom was hij van plan om die morgen de papieren goed door te nemen.
	Hij haalde zijn auto uit de garage en reed weg.
	Op weg naar het werk had hij die <u>ochtend</u> vertraging[,/.]
vf	*[omdat er/Er] was op de snelweg een lange file ontstaan.*
nvf	*[omdat er/Er] was op de snelweg politiebewaking.*
	Hij was blij dat hij wat eerder was vertrokken.
	Hij hield er niet van om te laat te komen.
	Verification sentence:
vf	Een file op de snelweg leidt tot vertraging.
nvf	Politiebewaking op de snelweg leidt tot vertraging.

English translation:
Mister Smith left his house at about eight o'clock. At work, he had to chair an important board meeting. That is why he had planned to study the papers thoroughly. He fetched his car from the garage and drove off. On his way to work that <u>morning</u> he was delayed[,/.]
vf: [because there/There] was a traffic jam on the highway.
nvf: [because there/There] were police patrols on the highway.
He was glad that he had left earlier. He hated to be late.
Verification sentence:
vf: A traffic jam on the highway causes delay.
nvf: Police patrols on the highway cause delay.

second clause of the causal construction. All filler probe words were nouns. The true filler probe words originated from the clause preceding the clause that had just been read. The verification sentences varied in content and referred to different portions of the texts. Since all of the experimental probe words and verification sentences were to be responded to with ‘true’, the filler items were used to introduce a ‘false’ condition. There were 12 filler texts with a ‘true’ probe word and a ‘false’ verification sentence, 18 filler texts with a ‘false’ probe word and a ‘true’ verification sentence, and 18 filler texts with a ‘false’ probe word and a ‘false’ verification sentence. Overall, 50% of the probe words and 42% of the verification sentences were to be responded to with ‘true.’

Procedure

The readers were instructed to read the texts carefully so as to understand them and to respond to the probe recognition task as fast as possible. They were also told that they had to judge a verification sentence after each text and that they had to give their judgement as fast as possible, but without making errors. The texts were presented on a computer display and the responses to the tasks were registered by a response panel with three buttons, the middle button for reading the texts and the outer two buttons for responding to the probe recognition and the verification task. Before the actual presentation of a text, a signal consisting of the words 'NEW TEXT' was shown on the screen. It stayed on the screen until the participants started reading the next text. When the participants pressed the middle button on the response panel, the words disappeared and the text appeared with the first line at the position of the signal. The texts were presented in a moving-window paradigm. The window consisted of one line of text containing a clause or a sentence. The line in the window was readable but the rest of the text, with the exception of spaces and interpunction characters, was replaced by dashes. This way, only one line of text could be read at a time. When the middle button was pressed, the line just read changed into a line of dashes and the next line became readable, thus preventing the reader from looking back in the text. At some place in the text, the text disappeared from the screen and a warning signal consisting of two asterisks appeared. The warning signal remained on the screen for one second. Participants were instructed to move their index fingers to the outer two buttons on the response panel. These buttons were labelled 'true' and 'false.' The probe word appeared at the same position as the warning signal. Participants were asked to react as quickly as possible to the probe word, deciding whether it had been present in the text they had just read. The response was given by pressing the 'true' or the 'false' button. After the decision had been made, the text reappeared continuing with the next line. When the last line of a text had been read, the text disappeared from the screen and the word 'VERIFICATION' appeared. It remained on screen for one second, during which the participants moved their index fingers to the 'true' and 'false' buttons. The participants had to decide as fast as possible whether the verification sentence was true or false with respect to the text they had just read. When the verification response had been given, the signal 'NEW TEXT' reappeared and the procedure started anew.

3.2.2 Results

Nine participants who had made four or more errors on the recognition of experimental probe words or on the judgement of the verification sentences, were excluded. The analyses were performed on the data of 32 participants.

Probe recognition times. The probe recognition times were analysed in two analyses of variance, one with participants as random variable (F_1) and one with items as random variable (F_2). The participants analysis contained participants group as a between factor and the items analysis contained items group as a between factor. These factors were entered to reduce the error variance, as suggested by Pollatsek and Well (1995). They recurred in all subsequent analyses of variance reported in this study. The participants analysis and the items analysis both contained two within factors: the familiarity of the causal relation (Familiarity) and the presence of the connective (Connective). Errors on the probe recognition task (7.8%) and outliers exceeding two standard deviations from the participant and item means within condition (0.1%) were excluded from the analyses.

Table 3.4: Mean probe recognition times (ms) as a function of Familiarity and Connective (Experiment 3).

	Connective	
Familiarity	present	absent
very familiar	1148	1233
not very familiar	1186	1180

The mean probe recognition times are given in Table 3.4.[1] There was

[1]The means presented are taken from the participants analysis. This is true for all subsequent tables unless stated otherwise.

no effect of Familiarity: $F_1(1,28) < 1$; $F_2(1,20) < 1$), and no effect of Connective: $F_1(1,28) = 2.09$, $MSE = 23660$, $p = 0.16$; $F_2(1,20) = 1.10$, $MSE = 21169$, $p = 0.31$. The interaction between Familiarity and Connective was marginally significant: $F_1(1,28) = 3.61$, $MSE = 18617$, $p = 0.068$; $F_2(1,20) = 2.95$, $MSE = 34332$, $p = 0.10$. Separate analyses of the recognition times in the very familiar condition revealed an effect of Connective: $F_1(1,28) = 4.37$, $MSE = 26551$, $p < 0.05$; $F_2(1,20) = 3.07$, $MSE = 36184$, $p < 0.05$ (one-tailed). Probe recognition times were shorter if the connective was present than if it was absent. Similar analyses of the not very familiar condition revealed no effect (both Fs < 1).

Verification times. The verification times were analysed with the same factors as the probe recognition times. Errors on the verification task (7.2%) were excluded from the analyses. The data were checked for outliers exceeding 2.0 *SD* from the participant and item means within condition, but none were found.

Table 3.5: Mean verification times (ms) as a function of Familiarity and Connective (Experiment 3).

	Connective	
Familiarity	present	absent
very familiar	2174	2324
not very familiar	2429	2505

The mean verification times are shown in Table 3.5. There was a main effect of Familiarity: $F_1(1,28) = 26.13$, $MSE = 58190$, $p < 0.001$; $F_2(1,20) = 5.86$, $MSE = 213980$, $p < 0.05$. The inferential information was verified faster in the very familiar condition than in the not very familiar condition. There also was a main effect of Connective. If the connective was present in the text, verifications were judged faster than if it was absent: $F_1(1,28) = 5.70$, $MSE = 71239$, $p < 0.05$; $F_2(1,20) = 15.24$, $MSE = 39566$, $p < 0.01$. No interaction between the factors Familiarity and Connective was found: $F_1(1,28) < 1$; $F_2(1,20) < 1$.

Reading times. The reading task consisted of reading the texts clause-by-clause (line-by-line). The target clauses, second clauses of the causal relations (line 6 of the texts), varied systematically with respect to the presence of the connective *because* in the two connective conditions. Therefore, the reading times were adjusted for clause length by means of a linear regression analysis (Ferreira & Clifton, 1986; Konieczny, 1996; Trueswell, Tanenhaus, & Garnsey, 1994). For each participant, a linear regression analysis was performed based on the reading times and clause lengths of clauses 2, 3, 4, 5, and 7 of all experimental texts. The target clauses (line 6) were not included. The resulting linear regression equations, indicating for each reader the influence of length on their reading times, were then used to adjust the reading times of the target clauses (see Appendix A for an explanation of this procedure). Reading times belonging to items on which the participant had made a verification error (7.2%) were excluded from the analyses. The data were checked for outliers exceeding 2.0 *SD* from the participant and item means within condition, but none were found.

Table 3.6: Mean linear regression reading time residuals (ms) after correction for clause length as a function of Familiarity and Connective (Experiment 3).

	Connective	
Familiarity	present	absent
very familiar	-176.34	-131.81
not very familiar	-135.44	-74.08

The resulting linear regression residuals were entered into analyses of variance for participants and items with the same factors as in the previous analyses. The means of these residuals are presented in Table 3.6. There was a significant effect of Familiarity: $F_1(1,28) = 2.98$, $MSE = 26151$, $p < 0.05$ (one-tailed); $F_2(1,20) = 3.49$, $MSE = 46732$, $p < 0.05$ (one-tailed).

Familiar clauses were read faster than less familiar clauses. There was no effect of Connective: $F_1(1,28) = 2.14$, $MSE = 41882$, $p = 0.15$; $F_2(1,20) = 2.34$, $MSE = 49938$, $p = 0.14$, nor was there an interaction between Familiarity and Connective (both Fs < 1).

3.2.3 Discussion

With respect to inferential processing, the results can be summarised as follows. The analyses of the probe recognition times gave evidence for inferential processing when the causal relation was very familiar and the connective present. The verification times analyses indicated that inferences were made if the connective was present. They also showed an effect of familiarity, but, as explained in Section 3.1, the difference between the sentences in the two familiarity conditions did not allow for a conclusion with respect to inferential processing in the very familiar and the not very familiar conditions. The reading times, finally, did not give evidence for inferential processing. The familiarity effect found could not be interpreted for the same reason as referred to above with respect to the verification times.

In Section 3.1, two models were defined for the familiarity distinction. According to the first model, the distinction reflects the difference between the knowledge of experts and novices, where the labels 'very familiar' and 'not very familiar' compare to 'expert' knowledge and no knowledge, respectively. The second model states that the familiarity distinction is to be viewed as two levels of 'expert' knowledge.

The results of the experiment do not support the expert-novice model, because this model states that readers make an inference independent of the presence of the causal connective *because* when processing very familiar causal relations and do not make an inference when processing not very familiar causal relations. The probe recognition times, the verification times, and the reading times should not differ in the conditions with and without the causal connective. The probe recognition times and the verification times clearly contradicted this.

The results were difficult to reconcile with the two-levels model, too. According to that model, no effect of the connective should be found for the very familiar causal relations, since an inference should be made with or without the causal connective. Thus, for very familiar causal relations, the probe recognition times, the verification times, and the reading times should not differ in the conditions with and without *because*. The effects of the connective found in the analyses of the probe recognition times and the verification times contradicted this. For the less familiar causal relations, the results were partly in line with the model. Here, the expectation was that the connective does play a role: Inferences are made if the connective is present. The verification times did confirm this expectation. However, the probe recognition times and the reading times did not. Evidently, the results do not support the second model either.

Assuming the results of the verification times to be accurate, the causal connective *because* has a strong influence on the processing of more or less familiar causal relations in the domain of everyday knowledge. If the connective is present, readers make the causal inference whether they are very familiar with the causal relation or not. According to this interpretation, the manipulation of the reader's knowledge about causal relations in the domain of general world knowledge differs from the manipulation of the reader's knowledge about causal relations in very specific knowledge domains (Noordman & Vonk, 1992; Noordman et al., 1992; Simons, 1993): Inferences are made dependent on the presence of the causal connective but irrespective of the reader's familiarity with the causal relation.

A problem with this interpretation is that it was not completely supported by the probe recognition data. If the results of the verification data are interpreted as giving evidence for inferential processing during reading dependent on the presence of the connective, an effect of the connective would have been expected for the probe recognition times as well. During the inferential process, it is assumed that both propositions of the causal relation, cause and consequence, are in memory and that recognition of a word contained in the first proposition, the consequence, is relatively easy. If no inference is made, the probe word has to be searched in the text representation built up so far, which takes more time. Therefore, assuming that the connective elicited an inference in both familiarity conditions, as was evidenced by the verification data, a difference in recognition speed should also have been found in both conditions. However, the recognition times only showed a difference in the very familiar condition but not in the less familiar condition.

A tentative explanation for these data is that the performance on the probe recognition task suffered from the complexity of the experiment. Participants not only had to make a decision on the occurrence of a particular word in the text, but also had to verify statements about the texts after reading. The verification task might have distracted them from performing well on the probe recognition task. This influence might have made itself felt more strongly in the recognition of probe words in the less familiar condition than in the very familiar condition, because, as mentioned earlier, the processing of very familiar causal relations generally is easier than that of less familiar causal relations. This explanation is tested in Experiment 4 by enhancing the familiarity of the causal relations and by changing the verification task.

Finally, the reading times showed no sign of inferential processing at all. The only effect found was that of familiarity: Clauses belonging to very familiar causal relations were read faster than those belonging to not very familiar causal relations. As explained before, no conclusions could be drawn regarding inferential processing based on a familiarity effect, because the two familiarity conditions consisted of different sentences. According to the explanation of the verification times given above, there should have been an effect of the causal connective in the reading times as well. Since inferential processing is time-consuming, an increase in reading times would have been expected if the connective was present. However, no such increase was found. A preliminary explanation for the absence of an effect of the connective in the reading times will be discussed in the general discussion of this chapter (Section 3.4).

3.3 Experiment 4

The inferential processing of more or less familiar causal relations in the domain of everyday knowledge seems strongly influenced by the presence of the causal connective, irrespective of the familiarity of the causal relation. This was concluded from the results of the verification task in Experiment 3, which evidenced the making of causal inferences in both familiarity conditions if the causal connective *because* had been present. However, the results of the probe recognition task in Experiment 3 only partly support this finding. As a tentative explanation, it was suggested that the probe recognition task suffered from the complexity of the experiment. The combination of a verification task and a probe recognition task might have influenced the participants' performance on the probe recognition task negatively and this influence might have made itself felt more strongly in the more difficult condition, that is, the condition with the less familiar causal relations. The present experiment was set up to test this explanation by enhancing the familiarity of the causal relation and by presenting the verification sentences at the end of the experiment instead of after each text. The enhancement of the familiarity was realised by inserting a sentence in the text that increased the availability of the inferential information to the reader. It was expected that these changes would allow for the detection of an effect of the connective in the probe recognition times of both familiarity conditions.

3.3.1 Method

Participants

Forty students, 24 women and 16 men ranging in age from 18 to 28, from Tilburg University were paid to participate. The results of 32 participants were entered into the analyses.

Materials

The same set of texts was used as in Experiment 3. A sentence was included before the causal construction that contained information by which the causal relation would become more familiar. It was made sure that these sentences differed in wording from the causal construction sentences, so that lexical repetition effects were avoided. For two texts, this implied changing the wording of the causal relation. An example of an included sentence before a causal relation is given in the textual example in Table

3.7.

Table 3.7: Example of a text with a very familiar (vf) and a not very familiar (nvf) causal relation in Experiment 4. The sentences with the information that heightens the familiarity of the causal relation are italicised. Probe words are underlined (English translation below).

	De heer Smit verliet rond half acht het huis.
	Hij moest op zijn werk een belangrijke vergadering voorzitten.
	Daarom was hij van plan om die morgen de papieren goed door te nemen.
	Hij haalde zijn auto uit de garage en reed weg.
vf	*Hij ergerde zich aan de vele auto's op de snelweg.*
nvf	*Hij ergerde zich aan de vele politiewagens op de snelweg.*
	Op weg naar het werk had hij die <u>ochtend</u> vertraging[,/.]
vf	[omdat er/Er] was lange file ontstaan.
nvf	[omdat er/Er] was een snelheidscontrole.
	Hij was blij dat hij wat eerder was vertrokken.
	Hij hield er niet van om te laat te komen.

English translation:
Mister Smit left his house at eight o'clock. At work, he had to chair an important board meeting. That is why he had planned to study the papers thoroughly. He fetched his car from the garage and drove off.
vf: *It bothered him that there were so many cars on the highway.*
nvf: *It bothered him that there were so many patrol cars on the highway.*
On his way to work that <u>morning</u> he was delayed[,/.]
vf: [because there/There] was a traffic jam.
nvf: [because there/There] was a speed check.
He was glad that he had left earlier. He hated to be late.

Procedure

The procedure was the same as in Experiment 3 (see Section 3.2.1), with one exception. Instead of presenting a verification sentence directly after each text, the verification sentences were shown consecutively after all texts had been read. This was done to ascertain that the reader's performance on the probe recognition task would be optimized. Participants were asked to verify the verification sentences on the basis of the texts they had just read. The purpose of the verification task in this experiment was to test the accuracy of the participants and the verification data were only used to select participants.

3.3.2 Results

As in Experiment 3, participants that had made four or more errors on the probe recognition task or on the verification task were excluded. This resulted in the exclusion of the data of 8 of the 40 participants. The data of 32 participants were entered into the analyses.

Probe recognition times. The analyses of the probe recognition times were similar to those of Experiment 3 and the same factors were analysed. Errors on the probe recognition task (11.3%) were excluded from the analyses. The data were checked for outliers exceeding 2.0 *SD* from the participant and the item means within condition, but none were found.

Table 3.8: Mean probe recognition times (ms) as a function of Familiarity and Connective (Experiment 4).

	Connective	
Familiarity	present	absent
very familiar	1076	1139
not very familiar	1110	1172

The probe recognition means are given in Table 3.8. There was no effect of Familiarity: $F_1(1,28) = 1.75$, $MSE = 20881$, $p = 0.20$; $F_2(1,20) = 2.72$, $MSE = 21495$, $p = 0.12$. There was a main effect of Connective: $F_1(1,28) = 7.47$, $MSE = 16816$, $p < 0.05$; $F_2(1,20) = 5.23$, $MSE = 15548$, $p < 0.05$. Probes were responded to faster if the connective had been present than if it had been absent. No interaction between Familiarity and Connective was found (both Fs < 1).

Reading times. As in Experiment 3, the reading times were adjusted for length by means of linear regression analyses per participant. The data were checked for outliers exceeding 2.0 *SD* from the participant and item means within condition, but none were found. The same factors were analysed as in the previous analyses.

Table 3.9: Mean linear regression reading time residuals (ms) after correction for clause length as a function of Familiarity and Connective (Experiment 4).

	Connective	
Familiarity	present	absent
very familiar	-31.37	-56.29
not very familiar	58.92	28.74

The mean linear regression reading time residuals are shown in Table 3.9. There was a main effect of Familiarity: $F_1(1,28) = 9.06$, $MSE = 27141$, $p < 0.01$; $F_2(1,20) = 5.74$, $MSE = 32149$, $p < 0.05$. The second clauses of the very familiar causal relations were read faster than those of the not very familiar causal relations. No effect of Connective was found: $F_1(1,28) = 1.93$, $MSE = 12588$, $p = 0.18$; $F_2(1,20) = 1.75$, $MSE = 10431$, $p = 0.20$, and there was no interaction between Familiarity and Connective: $F_1(1,28) < 1$; $F_2(1,20) < 1$.

3.3.3 Discussion

The results of the probe recognition times gave evidence for inferential processing in both familiarity conditions. In both the very familiar and the less familiar condition, the probe words were responded to faster if the connective was present than if it was absent. The results support the suggestion that in Experiment 3 the verification task had influenced the participants' performance on the probe recognition task. As to the effect of the familiarity enhancing sentence, the results were less clear. It was expected that the enhancement would cause the familiarity of the causal relations to increase, facilitating the making of the causal inference. Furthermore, the expectation was that the more difficult condition would benefit more from the enhancement than the less difficult condition, or, in other words, that the less familiar causal relations would benefit more from the enhancement than the very familiar causal relations. The results of the probe recognition times corroborated this, but the results of the reading times did not. In the reading times analyses, there still was a main effect of familiarity. A tentative explanation for this effect is that the enhancement influenced the processing of the causal relations in two ways. It might have raised the availability of the inferential information and facilitated the reading of the sentences. The first influence would affect the processing of the less familiar causal relations only. For these relations, the level of availability of inferential information, that is, the plausibility of the cause expressed in the second clause, is low and the enhancement sentence would have the effect of raising it to a sufficiently high level of activation for making the causal inference. Since the activation level of the inferential information in the very familiar causal relations is already high enough for making the inference, the enhancement sentence had no effect on the inferential processing of these relations. The second influence, then, might have affected the processing of the words of the causal sentences. By supplying a strong context to the causes of the causal relations, the processing of the causal relation sentences was facilitated. This suggestion is supported, tentatively, by a simple comparison of the (unadjusted) mean reading times of Experiments 3 and 4: The reading times of Experiment 4 were on average 400 ms shorter than those of Experiment 3. This effect, however, affected both types of causal relations equally, leaving their relative difference in familiarity intact.

As mentioned earlier (see Section 3.1), the familiarity effect in the reading times cannot be attributed to inferential processing. The finding of an effect of the connective in the probe recognition times, independent of familiarity, in this experiment together with the finding of the effect of the connective in the verification times in Experiment 3 for both familiarity conditions, suggested that the manipulation of familiarity as effectuated in this experiment has no influence on the making of the causal inferences.

The reading times gave no evidence of an effect of the presence of the connective. They did not support the results of the probe recognition times. This issue, together with the issue of the role of the familiarity of the causal relation, will be taken up in the next chapter.

3.4 General discussion

The two models of the reader's knowledge, 'expert'-'novice' knowledge and two levels of 'expert' knowledge, were based on studies on the inferential processing of causal relations in specific knowledge domains (Noordman et al., 1992; Simons, 1993). These studies showed that the reader's knowledge plays an important role in the inferential process. The experiments reported here investigated the role of the reader's knowledge in the processing of causal relations in the domain of everyday knowledge. The manipulation of familiarity in this domain did not appear to be comparable to the manipulation of knowledge in 'expert' knowledge domains. The manipulation of familiarity did not differentiate with respect to the inferential process.

The results of the probe recognition task in Experiment 4 supported the findings of the verification task in Experiment 3. Apparently, the inferential processing of causal relations in the domain of everyday knowledge depends heavily on the presence of the causal connective *because*. Readers only infer the information that justifies the causal relation if the connective is present. Their familiarity with the content of that information seems to be a prerequisite, too. However, familiarity in the domain of everyday knowledge is not the same as knowledge in a specific knowledge domain. Specific knowledge is dichotomous: It is known or it is not known, there is no middle way. That is why experts are able to make an inference about a specific causal relationship spontaneously (Simons, 1993). Their knowledge about the causal relation is highly available. Novices, in contrast, lack this knowledge altogether and will not make the inference even if a causal connective enables them to do so (Noordman & Vonk, 1992; Noordman et al., 1992; Simons, 1993). Familiarity, as defined in the present study, is more like a graded concept: One knows to a certain extent. This means that knowledge about plausible causes for everyday events is more or less available. The connective *because* functions as a trigger to bring this causal knowledge to the fore, enabling the reader to make the causal inference spontaneously. It seems, then, that the reader's knowledge as well as the presence of the connective are prerequisites for the making of causal inferences. In this light, it is hard to explain the finding of Simons (1993) that experts make an inference even in the absence of a causal connective (Simons, 1993, Exp. 8). A tentative explanation for this finding is that the participants in the experiment were extremely motivated to process the texts thoroughly. The fact that they were economics experts reading texts on economics in a psycholinguistic experiment may have led them to adopt the strategy of studying the texts rather than just reading them. This strategy is similar to the reading strategy that is evoked by setting the reader a particular reading task like inconsistency checking or pre-posed question answering. If this was the case, one would not expect the causal inferences to be made during normal reading, not even by experts, if the causal connective is not present.

Taken together, the results of the verification times and the probe recognition times in Experiments 3 and 4 suggest that an inference was made dependent on the presence of the causal connective. However, these results were not corroborated by the reading times analyses of the two experiments. No evidence of inferential processing was found in the reading times. It was expected that, since inferential processing is time-consuming, the reading times of clauses in which an inference is made are longer than the reading times of clauses in which no inference is made. Therefore, based on the results of the verification task and the probe recognition task, longer reading times would have been expected in the conditions where the causal connective was present. Why were they not found?

This question and the issue of the role of the familiarity of the causal relation are taken up in the next chapter. Experiments 5 and 6 were set up to take a closer look at the reading times. In Experiment 5, the same reading procedure was used as in the present experiments, but the clauses were split up into smaller units to allow for the measurement of reading times on parts of the sentences. Experiment 6 used the eye-movement registration technique to investigate reading comprehension.

CHAPTER 4

A closer look at reading times

4.1 Introduction

Experiments 3 and 4 gave evidence for the influence of the causal connective *because* on inferential processing. The causal inference was made if the connective was present. The evidence was obtained in a probe recognition task and a verification task. This finding led to the assumption that causal inferences in the domain of general world knowledge are made dependent on the presence of the causal connective *because* and independent of the familiarity of the causal relations.

A problem with this assumption was that the results of the reading times in these experiments showed no effect of the connective. It was hypothesised that the clause reading times of Experiments 3 and 4 would show an increase if the inference was made, since the making of inferences takes time. However, apart from a main effect of familiarity which could be attributed to the fact that the two familiarity conditions consisted of different sentences, the reading times showed no differences at all.

An important characteristic of the reading task used in Experiments 3 and 4 was that reading times were measured clause-by-clause. The reading times, therefore, reflected the processing of complete clauses. An explanation of why there was no increase in reading times when the connective was present is that the connective serves two functions. First, the connective suggests that an inference should be made. An inference leads to a longer reading time. This is the inference function of the connective *because*. The other function is that the connective indicates the way in which the clause has to be integrated with the previous context.

The connective *because* indicates that the reader has to establish a causal coherence relation between the clauses. This is the integration function of the connective. There is evidence in the literature for this integration function (Haberlandt, 1982; Millis, Golding, & Barker, 1995; Millis & Just, 1994; Sanders & Noordman, 2000). For instance, Haberlandt (1982) investigated the role of sentence-initial adversative and causal connectives and found a facilitating effect of these connectives on the reading of the immediately following words. The effect did not occur on the reading of the last words of the sentences. He suggested that "reading comprehension is facilitated when the reader's expectations are guided by the presence of a surface marker which explicates the semantic relationship between adjacent sentences" (p. 243). Similarly, Millis and Just (1994) found shorter reading times on the words following the connective *because* in causal sentences like:

> The elderly parents toasted their only daughter at the dinner because Jill had passed the exams at the prestigious university.

compared to the condition where the connective was absent:

> The elderly parents toasted their only daughter at the dinner.
> Jill had passed the exams at the prestigious university.

The distinction between integration and inference can be elucidated by considering what integration and inference contribute to the representation the reader constructs when understanding the sentences (Noordman & Vonk, 1997). As explained in Chapter 1, it is assumed that readers in understanding a text make different kinds of representations: a surface representation, a propositional representation, and a mental model representation (Fletcher, 1994; Johnson-Laird, 1983; Kintsch, 1998; Van Dijk & Kintsch, 1983). These representations differ with respect to the information they contain and with respect to their time characteristics. The surface representation is the representation of the literal wording of the text. This representation is not long-lived. On the basis of the surface representation, readers construct a propositional representation. This propositional representation represents the meaning of the sentences; the meaning is generally expressed in terms of propositions. The mental model representation is a further elaboration of the propositional representation. It contains information that is derived on the basis of world knowledge. These derivations, or inferences, are not explicitly expressed by the text but are intended by the writer. The inferences can be expressed by propositions, but the difference with the propositional representation is that inferences are derived from world knowledge and that the propositions are derived from the sentences. The propositional representation and the mental model representation are constructed later than the surface representation.

The integration and inference function of *because* could be seen as corresponding to the propositional representation and the mental model representation, respectively. Integration deals with the way in which propositions are related to each other. Inference deals with the construction of the mental model representation by adding world knowledge to the representation. In understanding the sentence *John was late because there was a traffic jam*, the reader assumes that a traffic jam is the cause for John being late. So the two clauses have to be integrated into a causal relation. At the propositional level, the understanding consists of constructing the propositions: P1(late, John), P2(is, traffic jam) and P3(because, P1, P2). It is precisely proposition P3 that achieves the integration between the two clauses. The inference, however, goes one step further. It consists of checking the causal relation as expressed by the sentence against the reader's world knowledge. This is achieved by deriving the general premise *In general, traffic jams cause a delay*. This is part of the reader's knowledge. By deriving this premise, the statement about John being late due to a traffic jam is justified. Represented in a proposition, the inferred world knowledge would be: P(cause, traffic jam, delay).

The two functions of *because* have opposite effects on processing. The integration function speeds up processing; the inference function slows it down. The benefit of the inferential processing is a deeper understanding of the text. Since integration affects the propositional representation, and inference the mental model representation, and since the propositional representation is assumed to be constructed earlier than the mental model representation, the integration effect is supposed to occur before the inference effect. That is to be expected also for the following reason. As soon as the reader reads the connective, it is clear, already, that the two clauses have to be integrated by a causal relation. The causal proposition can be constructed right away. The inference, on the other hand, cannot be made until the content of both clauses has been processed.

There is some evidence in the literature that inference processes occur at the end of a sentence. In general terms, Just and Carpenter (1980) show that, at the end of a sentence, extra processing takes place. This is the sentence wrap-up. Somewhat more specific evidence is obtained by Millis and Just (1994). In their study, in which they found a facilitative effect of the connective on the processing of the immediately following words, as reported above, they found an increase in reading times at the end of the *because* clause. They explained these results with a Connective Integration Model. According to this model, the connective signals that the second clause is to be integrated causally with the first, aiding the reader in integrating the words of the clause into the text representation. When finishing reading the sentence, the reader has to ”compute an appropriate inter-clause relation, which will consume resources” (p. 129). Millis and Just were not very specific about what the computation of an inter-clause relation actually means other than that it entails the re-activation of the first clause of the relationship. The present study takes this explanation one step further. It claims that at least part of the sentence wrap-up consists of inferential processes.

As suggested above, the differential effect of the connective *because* on the processing of causal relations is hypothesised to exert its influence on two different parts of the second clause of the causal relations. The facilitative effect of the integration function of the connective is said to influence the reading times of the words immediately following the connective and the slowing-down effect of the connective due to the inferential process is expected to show up in the reading times of the words at the end of the sentence.

A second finding of the experiments reported in Chapter 3 was that the making of inferences did not differentiate with respect to the familiarity of the causal relations. Evidence for inferencing was found in the verification times of Experiment 3 for very familiar causal relations as well as for less familiar causal relations. Based on this finding, it was expected that there would be no interaction between the influence of the connective and the familiarity of the causal relations.

4.2 Experiment 5

Experiment 5 investigates the influence of the causal connective *because* on reading in more detail than the previous experiments. Using the same self-paced moving-window technique as in Experiments 3 and 4, the texts were presented in small units, comprising one or more words. As in Experiment 3, the participants had to verify the information that could be inferred from reading the causal relation.

Apart from a differential effect of the connective *because* on the reading times, as explained above, it was expected that the connective would give evidence of inferential processing in the verification times. If the causal relation is signalled by the connective *because*, verification times should be shorter than if the causal relation is not signalled. The effects of the connective were expected not to differentiate with respect to the familiarity of the causal relations, which implies that there should be no interaction between the presence of the connective and the familiarity of the causal relation.

4.2.1 Method

Participants

Forty-six students from Nijmegen University were paid to participate, 32 women and 14 men, ranging in age from 18 to 25. The results of 40 participants were entered into the analyses.

Materials

The same 24 experimental texts that were used in Experiments 3 and 4 were split up into small units, consisting of one or more words. The causal relation sentences were divided into seven regions (see Table 4.1): 1) the first clause of the causal relation except the last word, 2) the last word of the first clause, 3) the connective *because*, 4) the first word of the second clause, 5) the middle part of the second clause, 6) the last part of the second clause, and 7) the first word of the clause following the causal relation. To achieve this division, the causal relations were slightly rewritten (see Appendix C for the rewritten materials).

Table 4.1: The seven regions of a causal relation with or without the connective *because* (example of a less familiar causal relation from Experiment 5, literal translation below).[a]

With connective

...

zijn auto / uit de garage / en reed weg. / ^{1a}Hij ondervond / ^{1b}een flinke
^{2}vertraging, / ^{3}omdat / ^{4}er / ^{5}een snelheidscontrole was / ^{6}op de snelweg. / ^{7}Hij

...

Without connective:

...

zijn auto / uit de garage / en reed weg. / ^{1a}Hij ondervond / ^{1b}een flinke
^{2}vertraging. / ^{4}Er / ^{5}was een snelheidscontrole / ^{6}op de snelweg. / ^{7}Hij

...

[a] A slash (/) indicates a unit border. Region numbers are positioned in superscript on the left side of the unit to which they belong.

English translation:

With connective:

his car / from the garage / and drove off. / ^{1a}He experienced / ^{1b}a big
^{2}delay, / ^{3}because / ^{4}there / ^{5}a speed check was / ^{6}on the highway. ^{7}He

Without connective:

his car / from the garage / and drove off. / ^{1a}He experienced / ^{1b}a big
^{2}delay. / ^{4}There / ^{5}was a speed check / ^{6}on the highway. / ^{7}He

The logic of dividing the causal relations into seven regions was as follows. Region 1 formed the first clause of the causal relation with the exception of the last word. It consisted of more than one unit (see, for example, 1^a and 1^b in Table 4.1). The reading times of region 1 were analysed as a check on the analyses of the reading times of the other regions. To that end, the reading times of the comprising units were summed.[1] Region 2 consisted of the last word of the first clause.[2] Since the last word of this clause was always presented at the start of the next line, it was separated from the first part of the clause. The reason for placing this region at the beginning of the next line followed from a requirement of Experiment 6 in which the same texts were used. For that experiment, it was mandatory that the second clause was preceded and followed by at least one unit on the same line that did not belong to the second clause. This will be explained in Section 4.3.1. Region 2 ended with a comma if the connective was present and

[1] It was not possible to perform the analysis on the reading times of (one of) the constituting units, because they varied in number and length between items.

[2] The only exception was item 7, where region 2 consisted of two short words.

with a period if the connective was absent. Region 3 contained the causal connective *because* and was absent in half of the conditions. Region 4 consisted of the first word after the connective, or, if the connective was absent, of the first word of the second clause. Region 5 represented the middle part of the second clause. This part of the clause was central to the meaning of the second clause. It expressed the cause of the causal relation. This region was rather large because of a change in word order in the conditions with and without the connective. In Dutch, the word order of a main clause is reversed in a subordinate clause. For instance, the middle region of the sentence in Table 4.1 which reads *een snelheidscontrole was* would change into *was een snelheidscontrole* in the condition without the connective. The verb *was* has moved from a position late in the sentence to a position earlier in the sentence. Region 5, therefore, always contained the same words but in a different order. Region 6 concluded the second clause with a prepositional phrase which was not central to the meaning of the clause. Finally, the line on which the second clause was presented ended with region 7, the first unit of the subsequent sentence. This unit actually was not part of the causal relation. The main regions of interest, that is, regions 5 and 6, were controlled for length in the two familiarity conditions (see Appendix D).

Each text was presented to each participant in one of four conditions: with a very familiar causal relation signalled by the connective *because*, with a very familiar causal relation without the connective, with a not very familiar causal relation signalled by *because*, or with a not very familiar causal relation without the connective. Since each text was presented to a participant in only one of the four textual conditions, there were four lists. The ordering of the 24 texts for each of these groups was the same but the textual conditions differed. The conditions were balanced over the four groups.

In addition to the 24 experimental texts, 24 filler texts were included. These texts resembled the experimental texts in topics and style, but contained connectives other than *because* (e.g., *but, while, after, when*). Furthermore, the filler texts varied in the number of clauses, from 6 to 11, and in the type of verification sentence.

Procedure

The same procedure was used as in Experiment 3 (see Section 3.2.1 for a detailed description), but there were two main differences. Firstly, the moving window consisted of one or more words instead of a complete clause, and secondly, there was no probe recognition task.

4.2.2 Results

The results of 40 of the 46 participants were entered into the analysis. Six participants had made four or more verification errors on experimental items and were excluded. The analyses were performed on the verification times and the region reading times of 40 participants.

Verification times. The analyses of the verification times were similar to those of Experiment 3 reported in Chapter 3. The verification times were analysed in two analyses of variance, one with participants as random variable (F_1) and one with items as random variable (F_2). The participants analysis contained participants group as a between factor and familiarity of the causal relation (Familiarity) and presence of the connective (Connective) as within factors. The items analysis was made with the between items factor items group and the within items factors Familiarity and Connective. Errors on the verification task (7.0%) were excluded from the analyses. The data were checked for outliers exceeding 2.0 *SD* from the participant and the item means within condition, but none were found.

Table 4.2: Mean verification times (ms) as a function of Familiarity and Connective (Experiment 5).

	Connective	
Familiarity	present	absent
very familiar	2244	2337
not very familiar	2389	2470

The mean verification times are given in Table 4.2. There was a significant effect of Familiarity: $F_1(1,36) = 24.26$, $MSE = 31978$, $p < 0.001$; $F_2(1,20) = 3.61$, $MSE = 134715$, $p < 0.05$ (one-tailed). Verification times were shorter in the very familiar condition than in the not very familiar condition. The factor Connective had an effect, too: $F_1(1,36) = 11.24$, $MSE = 27256$, $p < 0.01$; $F_2(1,20) = 14.64$, $MSE = 21001$, $p < 0.01$. Verification times were shorter if the connective was present. There was no interaction between Familiarity and Connective (both Fs < 1).

Reading times. Analyses of variance were performed on the reading times of regions 1, 2, 4, 5, 6, and 7, with the same factors as in the verification times analyses. The most important regions were the middle part of the second clause, region 5, and the final part of the second clause, region 6. Region 5 was expected to show the integrative effect of the presence of the causal connective, resulting in a facilitation if the connective was present. Region 6 was expected to produce an effect of the inferential process with longer reading times if the connective was present.

The reading times of region 1, the first part of the first clause, were analysed as a validity check on the other analyses. Since the region was the same in all conditions and was not affected by the experimental manipulation, no effects whatsoever should be found. No effects were predicted for region 2, the last word of the first clause. Region 3 was not analysed; it consisted of the connective *because*, which was present in only half of the conditions. An effect of the connective would be expected for region 4, the first word after *because* if present, because the presence of the connective facilitates processing, or because, in the absence of the connective, it would be the first word of the sentence, resulting in longer reading times. Region 7, the first unit of the sentence following the causal relation, was analysed to check for a possible spill-over effect of the processing of region 6.

In the analyses of regions following the connective, that is regions 4, 5, 6, and 7, the reading times belonging to items on which an error was made on the verification task were excluded from the analyses. For all analyses, outliers exceeding 2.0 *SD* from the participant and item means within condition were excluded (0.1% for region 6, and 0.3% for region 7). The mean reading times are given in Table 4.3.

The analyses of region 1, the summed reading times of the units of the

Table 4.3: Mean reading times (ms) of the seven regions of the causal construction as a function of Familiarity and Connective (Experiment 5).

		Region						
Familiarity	Connective	1	2	3	4	5	6	7
very	present	1508	490	419	378	611	555	450
familiar	absent	1508	500	-	415	646	531	437
not very	present	1504	477	417	375	655	605	454
familiar	absent	1483	487	-	412	699	563	439

first part of the first clause, showed no effects of Familiarity or Connective and no interaction between these factors (all Fs < 1).

The analyses of Region 2 showed no effect of Familiarity: $F_1(1,36) = 1.71$, $MSE = 4014$, $p = 0.20$; $F_2(1,20) = 1.50$, $MSE = 2497$, $p > 0.2$, no effect of Connective: $F_1(1,36) = 1.22$, $MSE = 3626$, $p > 0.2$; $F_2(1,20) = 1.25$, $MSE = 1858$, $p > 0.2$, and no interaction between these factors: $F_1(1,36)$ and $F_2(1,20) < 1$).

The reading times of region 4, the word after the connective, showed an effect of Connective: $F_1(1,36) = 39.39$, $MSE = 1323$, $p < 0.001$; $F_2(1,20) = 21.89$, $MSE = 1434$, $p < 0.001$. The reading times of this region were shorter if the connective was present. There was no effect of Familiarity nor was there an interaction between Familiarity and Connective (all Fs $<$ 1).

The analyses of the reading times of region 5, the middle part of the second clause, revealed an effect of Familiarity: $F_1(1,36) = 11.76$, $MSE = 8079$, $p < 0.01$; $F_2(1,20) = 5.71$, $MSE = 11231$, $p < 0.05$. The reading times were shorter in the very familiar condition than in the not very familiar condition. The factor Connective produced a significant effect: $F_1(1,36) = 11.59$, $MSE = 5316$, $p < 0.01$; $F_2(1,20) = 9.23$, $MSE = 5563$, $p < 0.01$. Reading times were shorter if the connective was present. There was no interaction between Familiarity and Connective (both Fs < 1).

In the analyses of region 6, the last part of the second clause, there was a main effect of Familiarity: $F_1(1,36) = 13.19$, $MSE = 5268$, $p < 0.01$;

$F_2(1,20) = 5.84$, $MSE = 10655$, $p < 0.05$. The reading times were shorter in the very familiar condition than in the not very familiar condition. There was an effect of the factor Connective, too: $F_1(1,36) = 8.59$, $MSE = 5100$, $p < 0.01$; $F_2(1,20) = 4.40$, $MSE = 5353$, $p < 0.05$. The reading times were longer when the connective was present. No interaction between these factors was found (both Fs < 1).

The analyses of region 7, the first word of the clause following the causal relation, showed no effect of Familiarity. They did show an effect of Connective, although this effect showed up in the items analysis only: $F_1(1,36) = 2.46$, $MSE = 3174$, $p = 0.13$; $F_2(1,20) = 8.30$, $MSE = 802$, $p < 0.01$. According to the items analysis, the reading times were longer if the connective was present than if it was absent. There was no interaction of Familiarity and Connective (both Fs < 1).

4.2.3 Discussion

The analyses of the verification times showed an effect of the connective: If the connective was present, the verification times were shorter than if the connective was absent. The experiment replicated the verification times results of Experiment 3. This result supported the conclusion that an inference was made during reading dependent on the presence of the connective.

The reading times analyses of region 1, the first part of the clause preceding the connective, were performed as a control for the other analyses. As expected, they showed no effects of familiarity or connective.

It was hypothesised that the connective *because* serves two purposes, aiding the reader in processing words following the connective by facilitating sentence integration, and eliciting an inference at sentence wrap-up time. The reading times analyses of the regions immediately following the connective, regions 4 and 5, showed that these regions were processed faster if the connective was present. For region 4, there is an alternative explanation. This effect can also be attributed to the fact that this region was in sentence-initial position if the connective was absent. In that case, the reading times might be longer simply because sentence-initial words take more time to read. The effect found in region 5, however, clearly supported the hypothesis that the connective facilitates sentence integration.

The reading times on the last part of the second clause, region 6, also supported the hypothesis. As was predicted, this region was processed more slowly if the connective was present than if it was absent. The slowing down points to inferential processing, a process that is assumed to take place at the end of the sentence (see Section 4.1). The results of the analyses of the region following the causal relation, i.e., region 7, suggested that this slowing-down effect of the connective may have spilled over. Region 7 did not belong to the causal sentence but to the next sentence. One would not expect the connective to have an effect on the processing of this region and, therefore, it is plausible that the effect, which is similar to the effect found in region 6, is attributable to the processing of the previous region.

Taken together, the experiment showed that the connective *because* does indeed produce two counteracting effects during reading: a facilitative effect on the reading of words directly following the connective, which is explained as a benefit to sentence-integrative processing, and a slowing-down effect at the end of the sentence processing attributable to inferential processing. To determine whether these counteracting effects cancelled each other out, as was hypothesised above, analyses were performed on the summed regions 4, 5, and 6. The analyses were performed in exactly the same manner as the other reading times analyses. There were 0.1% outliers. The mean reading times are given in Table 4.4.

Table 4.4: Mean summed reading times (ms) of the regions 4, 5, and 6 as a function of Familiarity and Connective (Experiment 5).

	Connective	
Familiarity	present	absent
very familiar	1541	1591
not very familiar	1636	1674

An analysis of the summed reading times of regions 4, 5, and 6 showed a significant effect of Familiarity: $F_1(1,36) = 28.24$, $MSE = 17908$, $p < 0.001$; $F_2(1,20) = 9.47$, $MSE = 32034$, $p < 0.01$. Familiar items were read faster.

The connective also had a significant influence: $F_1(1,36) = 6.99$, $MSE = 23334$, $p < 0.05$; $F_2(1,20) = 4.91$, $MSE = 19919$, $p < 0.05$. The reading times were shorter if the connective was present. There was no interaction between Familiarity and Connective (both Fs < 1).

The effect of the connective was not expected. Apparently, the two counteracting effects did not cancel each other out. Instead, the facilitative effect of the connective resulting from a benefit in sentence integration outweighed the reading time increase due to the inferential process. As shown above, the seventh region, the word following the causal sentence, showed an effect of the connective as well (items analysis). Assuming that this effect resulted from the spilling over of the inferential processing that occurred in the sixth region, or in other words, that the processing of the sixth region had not been completed, the summed regions analyses were re-run with the inclusion of region 7. The means of the reading times of the summed regions 4, 5, 6, and 7 were 2000, 2032, 2096, 2128, for the Familiarity by Connective conditions, respectively. In these analyses, there was a significant effect of Familiarity: $F_1(1,36) = 28.84$, $MSE = 15462$, $p < 0.001$; $F_2(1,20) = 9.53$, $MSE = 23200$, $p < 0.01$. Very familiar regions were read faster than less familiar regions. However, the effect of Connective had disappeared: $F_1(1,36) = 1.97$, $MSE = 20776$, $p = 0.17$; $F_2(1,20) = 1.73$, $MSE = 14162$, $p > 0.2$. There was no interaction between Familiarity and Connective (both Fs < 1).

If the clause reading times of Experiments 3 and 4 reflected the complete processing of the clauses and if the effect found at region 7 did indeed evidence a spill-over of the inferential processing in the final region of the second clause of the causal relation, the results of the analyses of the summed reading times of regions 4, 5, 6, and 7 would support the assumption that the absence of an effect of the connective in the clause reading times analyses of Experiments 3 and 4 was caused by the cancelling out of the two counteracting effects of the connective.

For almost all region reading times, as for the verification times, there was a main effect of familiarity. Familiar sentences and verifications were processed faster than less familiar sentences and verifications. As explained in the previous chapter, this effect cannot be used as evidence for inferential processing. Very familiar and less familiar causal relations differed in wording and content. However, in none of the analyses was there an interaction between familiarity and connective, which supports the view that the making of causal inferences in the domain of general world knowledge does not differentiate with respect to the familiarity of the causal relations.

Experiment 6 takes this investigation further by using a more natural reading paradigm, that of eye-movement registration during normal reading.

4.3 Experiment 6

In Experiments 3, 4, and 5, texts were presented in a self-paced noncumulative moving-window paradigm. The characters of the texts were replaced by dashes and only a part of the text, the window, was readable. Assuming that information is processed as soon as it is perceived (cf. Just & Carpenter, 1980), the reading times reflect the processing of the words contained in the window. Through this technique, information can be obtained about the way readers process a text. However, the technique has several disadvantages. The reading rate is lower than in normal reading. Readers are slowed down by the demands of the task: Each time a part of the text is read, they have to make the decision to press a button in order to be able to take in new information, and the time this takes is added to the time needed to process the text. Furthermore, readers are unable to look back in the text. In normal reading circumstances, readers often jump back in the text if they encounter a problem. They reread the word or the passage in which they believe lies the solution to their problem. In the moving window reading task, this is not possible. If a problem arises, the only thing the reader can do is pause and search for a solution in memory. The moving window reading times provide no insight into this process. The disadvantages of the self-paced moving window method affect the generalisability of the results (Rayner, 1998; Rayner, Sereno, Morris, Schmauder, & Clifton, 1989). The findings might be indicative of certain cognitive processes underlying reading but are restricted with respect to conclusions about fine-grained timing aspects of the normal reading process. Although the self-paced moving window technique, despite these disadvantages, has been used successfully in many studies of reading processes, a better way of studying ongoing reading processes is to have participants read a text and record their eye movements.

The eye-movement registration technique

Eye-movement patterns have been shown to provide insights into the nature of language processing in many fields of language research (for an overview, see Rayner, 1998; Rayner & Pollatsek, 1989). The on-line registration of eye movements allows the reader to read at a normal reading rate and since eye movements occur naturally in silent reading, no extra task has to be performed. The method is unobtrusive and, therefore, well suited for the study of language processes during reading.

The stream of continuous data resulting from eye-movement registration can be divided into saccades and fixations. When a reader reads a text, the eyes jump from one position in the text to the next. The average length of such a jump, or saccade, is 8 character spaces, ranging from 1 to 15 character spaces. The period of relative rest between two saccades is called a fixation. Readers typically spend about 200-250 ms on each fixation. The visual span during a fixation ranges from 3 character spaces to the left of the central point of vision to 15 character spaces to the right. At the central point of vision, the fovea, vision is sharpest. This area of sharp vision normally does not extend more than 7 character spaces to the right. A lot of research has been done on the determination of the factors influencing the length and the direction of saccades (forward or backward in the text) and the position and duration of the fixations (for a thorough review, see Rayner, 1998; Rayner & Pollatsek, 1989).

Apart from several low-level visual and perceptual factors such as visibility and motor control, saccades and fixations have been shown to be influenced by mental activities associated with language processing. For example, when reading a difficult text, the reader makes more and shorter saccades, more often jumps backward in the text, and spends more time on fixations. The relationship between eye-movement behaviour and language processing, however, is not a simple one. Just and Carpenter (1980) posited two assumptions which underly the interpretation of eye-movement data.

The first assumption is that all comprehension processes that operate on a word are started as soon the word is viewed. This means that no interpretation process is deferred. They called this the *immediacy assumption*. The second assumption, the eye-mind assumption, is that the eye remains fixated on a word as long as the word is being processed. Although there is indeed a relationship between the duration of a fixation on a word and the processing associated with that word, there are two flaws in these assumptions. First, not all words in a text are fixated. In fact, a lot of words, mostly function words, are skipped. That is not to say that they are not processed. It has been shown that they are perceived and processed in the fixation preceding the word. This means that a fixation duration does not necessarily reflect the processing of just the fixated word. A second problem is the existence of spill-over effects. It has been shown, for instance, that the prolonged processing time associated with fixating an infrequent word spills over to the next fixation (Rayner & Duffy, 1986). In short, although processing seems to be immediate, one should not jump to conclusions with respect to what has actually been processed.

As a measure of comprehension processes during reading, fixations do not suffice. Readers often fixate a word more than once, jump back in the text and reread a word, or read a word that has previously been skipped, and so on. A major issue in the study of eye-movement behaviour in relation to language comprehension processes has been the determination of an appropriate operationalisation of processing time. It seems that the appropriateness of a measure depends on the research question at hand and the materials studied. When studying lexical access processes, for instance, one might opt for first-fixation reading times of fixated words. If one is interested in higher-order processes, it seems reasonable to look at aggregational types of measures like gaze durations, i.e., summed fixation durations on words. The measures of processing time developed so far are first fixations, gaze durations, first-pass reading times, second-pass reading times, and regression path durations. Other measures are the probability of a fixation on a word, the probability of a regression into a word, the landing position in a word, and several statistics related to saccades. This last group of measures will not be discussed here.

The first investigators to use gaze durations were Just and Carpenter (1980). Gaze durations are the sums of the durations of all fixations a reader makes on a word before moving onto another word. Regressions into the word are not included. Another measure is first-pass reading time. It is used for the calculation of processing times of regions of a text larger than a word. First-pass reading times are obtained by calculating the durations of fixations in a region from the moment it is visited for the first time until the moment it is left in a forward or backward direction. It contains all fixations in the region, including any regressions made within the region. Second-pass reading times comprise all re-readings of a region (Frazier & Rayner, 1982). Regression path durations are the sums of fixations on a region including all regressive fixations made from that region into earlier regions until the region has been left in a forward direction (Konieczny, Hemforth, Scheepers, & Strube, 1995, who first coined the term). It should be noted that all of these measures aggregate on fixations only, and exclude the time spent on saccades. It is a moot point whether the time spent on saccades contributes to processing time (Irwin, 1998). This issue will be taken up in Chapter 5. As to the choice of measure, Rayner et al. (1989) suggest that, since most of these measures yield similar results, the best strategy is to examine them all if possible.

The measures of reading time used in Experiment 6

Eye-movement data provide insight into the temporal aspects of the reading process. They not only show how long readers pause on a particular part of the text but also how often that part is fixated. Thus, they allow for the separation of first-pass reading from subsequent re-readings. Because the causal relations studied in this experiment were straightforward and easy to understand, it was reasonable to expect effects of the manipulation of the presence of the causal connective to manifest themselves early in the comprehension process. The main interest in this study, therefore, lies in first-pass reading processes, where first-pass reading is defined as including those cases where a part of the text is read for the first time and has not been skipped on an earlier pass through the sentence.

For each region of the causal construction, the following first-pass measures were calculated: the first-pass *forward reading time* and the first-pass *regression path duration*. The first-pass forward reading time is a special case of the first-pass reading time which has been explained above

(see page 67). It is defined as the time spent on a part of the text until it is left in a forward direction. The first-pass regression path duration, which also has been explained above, is an extension of the first-pass reading time. It is defined as the time spent in a region until the region is left in a forward direction, including the time spent on all regressions to earlier parts of the text. The calculation of these measures is performed by aggregating the durations of the fixations on a region, including the durations of the intermittent saccades. The choice of using first-pass forward reading times as opposed to first-pass reading times as well as the decision to include saccade durations in the computation of the aggregational measures are justified in the next chapter, Chapter 5.

The first-pass forward reading time is a measure of ongoing reading. This measure is prone to suffer from lack of observations, since it does not include cases where the reader has decided to jump back in the text. This might happen, for instance, if the reader has encountered a problem and expects to find a solution in an earlier part of the text. The processing of the region itself is not concluded there but is continued in another part of the text. The first-pass regression path duration takes these cases of regression into account. This results in more observations than with the forward reading times but also in a greater variance. Reading times of regions that include a regression tend to be much longer than reading times of regions in which no regression occurs. Although this might lead to substantial differences in mean reading times over conditions, the increase in variance reduces the power of the statistical test.

The present experiment used the eye-movement registration technique to investigate the influence of the familiarity of the causal relation and the presence of the connective *because* on the processing of causal relations. The main difference with Experiment 5 was that readers were able to read the texts under more normal reading circumstances. They could view the text in its entirety and read as they normally do. It was expected that for the investigation of such higher-order comprehension processes as integration and inferring, the results of the two experiments would converge. The purpose of this experiment was to corroborate the findings of Experiment 5, i.e., that the causal connective *because* is a prerequisite for making causal inferences in the domain of everyday knowledge and also that it facilitates sentence integration. Finding the same results would considerably strengthen the conclusions drawn in Experiment 5.

The main difference between Experiments 5 and 6 was that the investigation of the processing of causal relations occurred in a normal reading setting. The texts were presented in their entirety on the screen, allowing readers to look back in the text if they wanted to. Although this behaviour was not encouraged in the experiment - they were asked to read thoroughly but quickly - the simple fact that they could look back was what would give them the feeling of being able to read normally. Furthermore, no pressure was exerted to respond to the verification task very quickly. The verification task was used solely for the purpose of urging the participants to read well. The verification times, therefore, were not used in this experiment.

The same texts were used as in Experiment 5. This allowed for a direct comparison of the reading times results. It was expected that the presence of the connective *because* would have two effects on the processing of the causal relation. It would enhance sentence integration and elicit a causal inference. These effects were expected to occur in the middle and the last region of the second clause, respectively. As in the previous experiment, the reading times of the middle region would have to be shorter if the connective is present than if it is absent, providing evidence for a facilitation of sentence integration. The reading times of the last region of the second clause, on the other hand, would have to be longer if the connective is present than if it is absent, providing evidence for inferential processing.

4.3.1 Method

Participants

Forty-nine students of Nijmegen University (all with normal, uncorrected vision) were paid to participate, 34 women and 15 men, ranging in age from 20 to 27. Of these participants, 40 were entered into the final analysis.

Materials

The same texts were used as in Experiment 5. As mentioned in Section 4.2.1, the positioning of the regions of the causal relations was restricted by demands of the present experiment. It was made sure that the regions of interest, that is, the middle and the last regions of the causal relations (regions 5 and 6, see Table 4.1), were always presented in the middle of the screen. The beginning and the end of the line in which these regions occurred always consisted of less important regions. The reason was that at the beginning and the end of the line specific eye movements occur that are associated with making a large jump, the so-called return sweep. When a reader encounters the end of a line of text, a very big jump has to be made to the beginning of the next line. It is often the case that this jump is initiated before the end of the line is actually reached, because the reader has perceived and processed the last word on the line in the fixation on the word(s) preceding it. Another problem occurs when the eyes land on the words at the beginning of the next line. Since the return sweep is very big, the first fixation is often off-position and followed by a corrective second fixation. The measurements of fixation times on the beginning and the end of lines of text are therefore blurred by these extra processes.

Apparatus

The stimuli were presented at a refresh rate of 72 Hz on a NEC Multi-Sync 5FG colour monitor. The stimulus presentation was controlled by a personal computer (Intel 486dx2-50) with a VGA graphics adaptor. The data was recorded by another personal computer of the same type. Horizontal and vertical eye movements of the right eye of the participant were sampled at a rate of 200 Hz (5 ms per measurement) by an Amtech ET3 infrared pupil reflectance eye tracker (Katz, Müller, & Helmle, 1987). The eye tracker has a spatial resolution of 5 to 10 minutes of arc, that is, approximately 0.25 degrees of visual angle.

Participants were restricted in their head movements by the use of a chin rest, a forehead rest, and a bite bar (with dental impression compound). The distance between the participant's eye and the monitor screen was 59 cm. At this distance, the display area used for text presentation subtended 22 degrees of visual angle horizontally and 12 degrees vertically. The texts were presented in graphics mode (800 x 600) in a black non-proportional font (Courier New, 12 pt.) on a light grey background. Lines of text were separated by a white line. Each character subtended approximately 0.28 degrees of visual angle.

Procedure

Before the experiment, each participant was submitted to a Landolt vision test. Participants that did not pass the test were not entered into the experiment. After the participant had been seated and the equipment adjusted, the experiment began with a calibration task. The calibration screen consisted of twelve small boxes of the size of a character, equally distributed over the display area, that is, the area in which the texts were to be presented. At the experimenter's request, the participant started the calibration task by pressing the right-hand button. The calibration routine involved fixating the twelve boxes consecutively and pressing the button each time a crosshair inside the box was fixated. The routine was performed twice. After the calibration, the experiment started with three practice items. Each item consisted of an asterisk, followed by a text, a verification sentence, and a re-calibration task. The asterisk remained on the screen until the participant was ready to start reading the next text. At the press of the right-hand button, the text appeared at exactly the same position as the asterisk. The instruction to the participant was to read the text thoroughly but quickly, in order to understand it. Immediately after the text had been read and the button pressed, the text disappeared and a verification sentence was presented below the place where the text had ended. The verification task consisted of judging whether the verification sentence was true or false according to the text. The response consisted of pressing either the left-hand ('false') or the right-hand ('true') button. After the verification task had been concluded, a re-calibration routine was started. It consisted of four calibration points presented in the centre of the screen. The re-calibration routine was similar to the main calibration routine. After the re-calibration had been concluded, the asterisk for the next item appeared on the screen.

The experiment consisted of two blocks of 24 texts. Each block was preceded and followed by a major calibration. Between the blocks there was a break, allowing the participant to take a rest. The total duration of the experiment was one hour.

4.3.2 Results

Seven participants who had made four or more errors on the verification task, were excluded from the analyses. The analyses were performed on the data of 40 participants.

With a fixation analysis program (see Cozijn, 1994), the data were calibrated and saccades and fixations were calculated. Saccades were determined using a velocity threshold algorithm with a starting threshold of 0.30 degrees per second and an ending velocity of 0.10 degrees per second. The minimum saccade amplitude was set to 0.20 degrees. Eye movements with an amplitude below this value were not considered to be saccades. Fixations were defined as the intervals between saccades. The calibration data as well as the resulting saccades and fixations were checked for errors and anomalies, which were rejected. The assignment of the fixations to the words in the texts was performed manually for each text.

As in Experiment 5, the causal relations were divided into seven regions (see Table 4.1). Region 3, which consisted of the connective *because*, was not analysed, for the obvious reason that the connective was not present in half of the conditions. Analyses were performed on regions 1, 2, 4, 5, 6, and 7, as well as on the joined regions 4, 5, and 6. The analyses of the joined regions served to make a comparison possible with the clause reading times obtained in Experiments 3 and 4, and the reading times of Experiment 5.

First-pass forward reading times

The reading times analyses were carried out as in Experiment 5 with the same factors. Reading times belonging to items on which the participants had made a verification error (5.7% of the data) as well as outliers based on participants and item means (on 2.0 *SD*) were excluded from the analyses. Apart from these excluded observations, there were several missing data as a result of skipping or blinks. Since all regions were analysed separately for each of the two dependent measures, the percentage of valid observations is reported per analysis. The mean first-pass forward reading times of the seven regions are given in Table 4.5.

Region 5, the middle region of the second clause, showed no effect of Familiarity: $F_1(1,35) = 1.25$, $MSE = 10363$, $p > 0.2$; $F_2(1,20) < 1$. The factor Connective had a significant effect: $F_1(1,35) = 7.28$, $MSE = 20054$,

Table 4.5: Mean first-pass forward reading times (ms) of the seven regions of the causal construction as a function of Familiarity and Connective (Experiment 6).

		Region						
Familiarity	Connective	1	2	3	4	5	6	7
very	present	1101	340	243	193	604	412	199
familiar	absent	1102	310	-	221	652	366	206
not very	present	1095	328	230	226	613	449	208
familiar	absent	1110	314	-	273	681	428	195
% observations		82.7	58.3	29.2	22.5	79.3	76.6	56.4

$p < 0.05$; $F_2(1,20) = 16.11$, $MSE = 10152$, $p < 0.01$. The region was read faster if the connective was present than if it was absent. No interaction between Familiarity and Connective was found (both Fs < 1).

In region 6, the final part of the second clause, the familiarity of the causal relation played a significant role. The region was read faster in the familiar condition compared to the less familiar condition: $F_1(1,36) = 10.87$, $MSE = 8995$, $p < 0.01$; $F_2(1,20) = 7.25$, $MSE = 9626$, $p < 0.05$. The presence of the connective had a significant effect: $F_1(1,36) = 9.06$, $MSE = 4903$, $p < 0.01$; $F_2(1,20) = 2.90$, $MSE = 9502$, $p < 0.05$ (one-tailed). Contrary to the effect found in region 5, this region was processed slower if the connective was present than if it was absent. There was no interaction between Familiarity and Connective (both Fs < 1).

Analyses of variance were carried out for regions 5 and 6 combined, forming two levels of a new factor called Region. It was expected that the factor Region would interact with the factor Connective, because the separate analyses of the middle region and the final region showed opposite effects of the factor Connective. The interaction between Region and Connective was significant: $F_1(1,36) = 11.12$, $MSE = 15320$, $p < 0.01$; $F_2(1,20) = 12.88$, $MSE = 12679$, $p < 0.01$. In this analysis, there also was a main effect of Familiarity: $F_1(1,36) = 13.30$, $MSE = 6679$, $p < 0.01$; $F_2(1,20) = 3.22$, $MSE = 14977$, $p < 0.05$ (one-tailed). Reading times in the very familiar condition were shorter. The factor Connective was significant only in the analysis by items: $F_1(1,36) = 1.69$, $MSE = 9793$, $p > 0.1$; $F_2(1,20) = 4.04$, $MSE = 7027$, $p < 0.05$ (one-tailed). There were no other effects (all Fs < 1).

The analyses of regions 1, 2, and 7, separately, revealed no effects (all Fs < 1). The analysis of region 4, the word after the connective *because*, showed an effect of Familiarity: $F_1(1,6) = 6.31$, $MSE = 1649$, $p < 0.05$; $F_2(1,6) = 2.91$, $MSE = 1466$, $p > 0.1$. However, as can be seen from the degrees of freedom in this analysis, this effect is not very reliable.

Table 4.6: Mean first-pass forward reading times (ms) of the joined regions 4, 5, and 6 of the causal construction as a function of Familiarity and Connective (Experiment 6).

	Connective	
Familiarity	present	absent
very familiar	1222	1185
not very familiar	1314	1327

The means of the first-pass forward reading times of the joined regions 4, 5, and 6[3] are given in Table 4.6. The results only showed an effect of the factor Familiarity. Familiar joined regions were read faster: $F_1(1,36) = 14.74$, $MSE = 35143$, $p < 0.01$; $F_2(1,20) = 4.71$, $MSE = 77364$, $p < 0.05$ (one-tailed). There was no effect of Connective and no interaction between Connective and Familiarity (all Fs < 1).

First-pass regression path durations

The means of the first-pass regression path durations are given in Table 4.7. Similar results were obtained as in the reading time analyses. In region 5, Familiarity showed an effect only in the analysis by participants: $F_1(1,36) = 10.52$, $MSE = 23645$, $p < 0.01$; $F_2(1,20) = 2.71$, $MSE = 39110$, p

[3]In order to obtain the joined reading times of regions 4, 5, and 6, the regions were joined together into one large region and the procedure of aggregating fixations and saccades was performed on this large region.

> 0.1. The effect of the presence of the connective was significant: $F_1(1,36) = 17.89$, $MSE = 18709$, $p < 0.001$; $F_2(1,20) = 16.73$, $MSE = 11505$, $p < 0.01$. The region was read faster if the connective was present than if it was absent. There was no interaction: $F_1(1,36) = 1.88$, $MSE = 23580$, $p = 0.17$; $F_2(1,20) < 1$.

Table 4.7: Mean first-pass regression path durations (ms) of the seven regions of the causal construction as a function of Familiarity and Connective (Experiment 6).

		Region						
Familiarity	Connective	1	2	3	4	5	6	7
very familiar	present	1183	352	297	251	647	491	261
	absent	1165	334	-	324	715	426	247
not very familiar	present	1204	328	309	257	702	580	238
	absent	1148	341	-	323	817	505	275
% observations		92.7	60.8	45.6	31.6	92.7	91.6	61.6

In region 6, familiar items were read faster than less familiar items: $F_1(1,36) = 11.59$, $MSE = 24440$, $p < 0.01$; $F_2(1,20) = 10.37$, $MSE = 16803$, $p < 0.01$. This region also showed a significant effect of Connective: $F_1(1,36) = 11.37$, $MSE = 17282$, $p < 0.01$; $F_2(1,20) = 8.15$, $MSE = 14925$, $p < 0.05$. The regression path durations were longer if the connective was present than if it was absent. The analyses of this region revealed no interaction (both Fs < 1).

In the combined analysis of regions 5 and 6, the interaction between Region and Connective was significant: $F_1(1,36) = 27.71$, $MSE = 18892$, $p < 0.001$; $F_2(1,20) = 18.47$, $MSE = 16846$, p < 0.001. There also was an effect of Familiarity: $F_1(1,36) = 29.88$, $MSE = 17818$, $p < 0.001$; $F_2(1,20) = 10.19$, $MSE = 27315$, $p < 0.01$. Familiar items were processed faster. There was no effect of the factor Connective and no interaction between Familiarity and Connective (all Fs < 1).

Except for region 4, no other effects were found. In this region, the connective had a significant effect[4]: $F_1(1,16) = 9.11$, $MSE = 11636$, $p <$

0.01; $F_2(1,15) = 14.37$, $MSE = 6259$, $p < 0.01$. No other effects were found in this region (all Fs < 1).

Table 4.8: Mean first-pass regression path durations (ms) of the joined regions 4, 5, and 6 of the causal construction as a function of Familiarity and Connective (Experiment 6).

	Connective	
Familiarity	present	absent
very familiar	1299	1289
not very familiar	1438	1424

The means for the first-pass regression path durations of the joined regions 4, 5, and 6 are given in Table 4.8. As in the analyses with first-pass forward reading times, the only effect found was that of Familiarity: $F_1(1,36) = 30.69$, $MSE = 24471$, $p < 0.001$; F_2(1,20 = 5.12, $MSE = 78618$, $p < 0.05$. There were no other effects (Fs < 1).

Regressions

Regressions occurred relatively often. For regions 5 and 6, the percentage of regressions was 13.7% and 15.0%, respectively. If one takes a closer look at the regressions, it seems that they were not equally distributed over the conditions in this experiment.

In Table 4.9, it can be seen that for regions 4 and 5 most regressions occurred in the conditions where the connective was absent and for region 6 in the conditions where the connective was present. However, χ^2-analyses of the regression patterns in the regions revealed that only the patterns of regressions in region 6 and 7 tended to deviate from expectancy. Region 6: $\chi^2 = 7.61$, $df = 3$, $p = 0.055$; Region 7: $\chi^2 = 7.41$, $df = 3$, $p = 0.060$ (for the other regions, $p > 0.2$).[5]

[4] It should be noted that this result is based on only a small number of observations (31.6%).

[5] The pattern of regressions in region 7 differed from that in region 6, but because of the low percentage of regressions in region 7 (5.1%), this result was rather unreliable.

Table 4.9: Percentage of regressions in the seven regions of the causal relation as a function of Familiarity and Connective (Experiment 6).

		Region						
Familiarity	Connective	1	2	3	4	5	6	7
very	present	10.8	2.5	15.0	8.3	11.7	14.2	7.1
familiar	absent	8.3	2.9	-	11.7	12.1	12.1	3.3
not very	present	13.3	0.8	17.9	6.3	14.2	20.8	2.9
familiar	absent	8.3	3.8	-	10.4	16.7	12.9	7.1

4.3.3 Discussion

The results of the first-pass forward reading times and the first-pass regression path durations were very much in line. Both measures pointed to a facilitative effect of the connective *because* on the processing of the middle region of the sentence (region 5) and a slowing-down effect on the final region of the sentence (region 6). This conclusion was supported by the results of the combined analyses of regions 5 and 6, where an interaction was found of the factors Region and Connective.

The analyses of regions 1 and 2, comprising the clause that precedes the cause-part of the causal construction, revealed no effects of familiarity and connective. Region 1 was the same for all conditions, so no differences were expected. Region 2 differed with respect to the connective condition. If the connective was present, the region ended a clause, and if the connective was absent, it formed the end of a sentence. Apparently, the time it took to wrap up the clause did not differ from the time it took to wrap up the sentence. Region 4, consisting of the word immediately following the connective, was fixated in only a small number of cases. It showed an effect of the presence of the connective, but this effect could not be attributed unambiguously to a facilitation of sentence processing as in region 5. The effect could also have been brought about by longer processing times in the condition when the connective was absent, because then region 4 was the first word of the sentence. The analyses of region 7 showed no effects of the connective. Apparently, there were no spill-over effects of the processing of region 6 into region 7, which suggests that this effect was an artefact of the reading task in Experiment 5.

The results of the reading times analyses were supported by the distributions of regressions over the conditions. If regressions are taken as indicators of processing difficulty, the distribution of regressions in region 6 was in accordance with the hypotheses. In this region, where the reader was expected to make an inference which requires extra processing time, more regressions were found when the connective was present. This explains why bigger differences were obtained for the first-pass regression path durations than for the first-pass forward reading times. It seems that, if regression durations are taken into account, the effects of the connective on the processing of regions 5 and 6 were enhanced. For region 6, this does not come as a surprise, since the process of making the causal inference elicits the reinstatement of the information contained in the sentence, and regressions back into the text could very well serve that purpose. For region 5, however, this is not so obvious. The connective is expected to facilitate the integration of the consecutive words into the sentence representation, and it is assumed that this process takes place immediately upon processing the words. To detect this effect, the first-pass forward reading time is a more suitable measure than the first-pass regression path duration, for the first-pass forward reading time reflects the ongoing immediate processing of the words in the region. Averaged over familiarity, the mean forward reading times in region 5 were 608.5 ms with connective and 666.5 ms without connective (see Table 4.5), and the mean regression path durations were 674.5 ms with connective and 766 ms without connective (see Table 4.7). A direct comparison of these means in the condition without connective shows that the mean regression path durations were 99.5 ms longer due to the inclusion of regression durations versus only 66 ms in the condition with the connective. The greater main effect of Connective in the regression path analyses of region 5 could thus be attributed to a greater increase in processing time in the conditions where the connective was absent. The data suggest that the results of the regression path analyses for this region reflected the disadvantage of the absence of the connective. And this was exactly what the other measure of processing time did not show.

For region 6, the means were 430.5 ms, 397 ms, 535.5 ms, and 465.5 ms, for the forward reading times with and without connective and the regression path durations with and without connective, respectively (see Tables 4.5 and 4.7). The mean regression path durations were 105 ms longer than the mean forward reading times in the condition with connective and 68.5 ms longer in the condition without connective. In this case, the greater contribution to the reading times of the regression durations in the condition with connective is quite understandable, because in this condition an inference was made and the process of making a regression can well be seen as subservient to the process of inferring.

The separate analysis of the joined regions 4, 5, and 6 of the causal relations was performed in order to be able to compare the reading times results of this experiment with Experiments 3 and 4. Experiments 3 and 4 failed to show the slowing-down effect of the making of an inference on the clause reading times. The suggestion that the increase in reading time due to the making of an inference at the end of the sentence was cancelled out by the decrease due to the enhancement of the integration process in the middle of the sentence was corroborated by the results of the analysis of the joined regions 4, 5, and 6 in this experiment. The analysis of the joined regions did not reveal any effect of the connective whatsoever. This finding also gives support to the conjecture that in Experiment 5 the processing of region 6 had spilled over to region 7. With the inclusion of region 7, the joined regions analyses of Experiment 5 were in line with the results of Experiment 6 and also supported the suggestion that in Experiments 3 and 4 the two processes cancelled each other out.

In this experiment, too, no interactions were found between the familiarity of the causal relation and the presence of the causal connective. This, again, supported the idea that the making of causal inferences in the domain of general world knowledge is not sensitive to the familiarity as manipulated in the present study.

4.4 General discussion

In Experiment 5, using a self-paced noncumulative moving-window technique, evidence was found for a facilitating effect of the connective *because* on the processing of the words immediately following it. The second finding was an increase in processing time of the final part of the sentence as a function of the presence of the connective. Finally, the response times on a verification task were shorter when the connective had been present in the text. Experiment 6 replicated the results of Experiment 5 using a more detailed method for the study of reading processes. The first-pass forward reading times and the first-pass regression path durations each capture a different type of reading behaviour. The behaviour of readers who progress through a text and solve reading difficulties on the way is best captured by the first-pass forward reading times. The tendency of readers to jump back in the text in order to solve reading problems, on the other hand, is best reflected in first-pass regression path durations. In this respect, the two measures are complementary. The analyses of the two dependent measures of processing time revealed, overall, the same effects for the connective *because*: a facilitation of the reading of the words following the connective and a slowing down at processing the last part of the sentence.

The results confirmed the hypothesis that the connective aids readers in integrating the words of the cause of the causal relation into meaning structure of the sentence. The connective guides readers in the construction of the representation of the sentence. It signals that the sentence consists of a consequence-cause construction and that the words following it should be integrated into the cause-part of the structure. This way, readers are relieved of the time-consuming task of building a structure themselves. This result is in line with earlier studies of the function of connectives during discourse processing (Haberlandt, 1982; Millis & Just, 1994).

The second result of the reading times analyses is attributed to the process of inference. The connective *because* elicits the inferring of the major premise of the causal chain of reasoning underlying the causal relation. Since this process takes time, an increase in reading time is found if the inference is made. Crucial to the making of this inference is whether the reader already has knowledge about the information to be inferred. Simons (1993) found evidence for the inferential process only for experts on the subject of the causal relations. Novices with respect to these relations did not make the inference. The present study extended the findings of Simons (1993) to the domain of everyday knowledge. The distinction in this study was not between readers who have knowledge about the causal relation and readers who do not have this knowledge, but between causal relations that are very familiar to the reader versus causal relations that are not very familiar. Apparently, this distinction is not comparable to the expert-novice distinction made by Simons. In none of the experiments reported here, was there an interaction between the presence of the connective and the familiarity of the causal relation. The distinction between high and low familiarity is best explained as two gradations of expert knowledge. Readers process highly familiar and less familiar causal relations in the domain of general world knowledge in the same way as experts process causal relations in their specific knowledge domain. However, the presence of the causal connective is necessary for the inference to be made.

The results of the reading times analyses of Experiments 5 and 6 explain why no reading times effects were found in Experiments 3 and 4. In these experiments, the reading times reflected the processing of the complete second clause of the causal relation. From the results of Experiments 3 and 4, it can now be concluded that the counteracting effects of the speeding up of the reading process due to the facilitation of the sentence integration process and the slowing down due to the inferential process cancelled each other out. This conclusion was supported by the joined regions analyses of Experiments 5 and 6.

The noncumulative moving window method of Experiment 5 and the eye-movement registration technique of Experiment 6 produced similar results. However, there was one difference. In Experiment 5, a spill-over effect was found of the processing of the final region of the causal relation, region 6, to the first region of the next sentence, region 7. Experiment 6 did not show this effect. The spill-over might be explained as a result of the reading task and the method of textual presentation in Experiment 5. In the moving window paradigm, the texts were masked out and participants were only able to read what was shown in the window. They had to press a button each time a window was read. Regions 6 and 7, which each consisted of one window, were presented on the same line on the screen. This line contained the second clause of the causal relation but ended with region 7, which was the start of a new sentence. This presentation might have led readers to press the button while processing the final region of the causal relation sentence before the processing of that region was completed. Readers might have read on to the end of the line, realising only then that the sentence had ended on the previous region. In that case, the processing of region 6 would be completed at region 7.

When readers are allowed to read the text in its entirety, as in Experiment 6, no spill-over effect is found, which gives rise to the contention that the spill-over effect is an artefact of the noncumulative moving window method. The interpretation of the results when this method is used, therefore, should be made with care. The eye-movement registration technique as used in the present study does not suffer from this flaw. It is a better method for the study of reading processes as they naturally occur.

CHAPTER 5

Methodological issues

5.1 Introduction

In the determination of appropriate measures of reading time, the previous chapter raised two issues. The first issue bears on the calculation of first-pass reading times. The suggestion is made to abandon the traditional way of determining first-pass reading times in favour of a method that takes into account that regressions are made. A justification for this different approach, resulting in a measure called first-pass *forward reading times*, is given in Section 5.2. The second issue deals with the inclusion of saccades in the calculation of reading times. In general, aggregational measures of reading time are obtained from fixation durations only, while saccade durations are ignored. However, linguistic processing does not stop when readers make a saccade to the next fixation position. This issue is taken up in Section 5.3.

What measure of reading times to use is an issue in itself in the current eye-movement reading research. Over the years, several measures have been developed (for an overview see Rayner, 1998; Rayner & Sereno, 1994a). The choice of a measure depends on the unit of analysis, i.e., either a single word or a larger region of text, and on the cognitive processes studied. If the unit of analysis is a word, the measures *first-fixation duration*, *gaze duration* (the sum of consecutive fixations on a word before a saccade to another word is made), and *total fixation time* (the sum of the gaze duration on a word and the fixation time resulting from any regressions made to that word) have been shown to be successful. For regions larger than a word, the measures *first-pass reading time* (the sum of all fixations that occur within a region before a saccade out of that region is made), *second-pass reading time* (the sum of all fixations on a region when it is re-read), and *total reading time* (sum of the first and the second-pass reading times) have been developed. If the cognitive process at issue is expected to occur early during the processing of a word or region, measures are used that reflect *first-pass reading times* of that region. Processing that is assumed to occur later during comprehension is investigated with *second-pass reading times* or *total reading times*. In addition to these reading time measures, *the probability of fixating a word or region* and *the number of regressions to a word or region* have been used as well.

A point of special interest is how to capture the processing time associated with regressions. In normal reading, 10 to 15% of the eye movements are directed backward in the text. It is assumed that regressions occur as a result of processing difficulty. The reader detects a problem and decides to look back in the text to solve it. One approach to investigate this behaviour is by using the *second-pass reading times* or the *total reading times* of the regions to which the eyes have been redirected (Rayner, 1998). Although these measures are informative about the time spent on a region in re-analysis, that is, in comparison with their first-pass reading time measures, they convey no information about the source of re-analysis. Therefore, other approaches to the analysis of regressions have been developed where the regression time is associated with the region in which the regression is initiated. The *regression path duration* is the sum of all fixation durations starting with the first fixation on a region and including all fixation durations, also on earlier words, up to the point where the region is left with a forward saccade (Konieczny, 1996). The *re-reading time* is the *regression path duration* of a region with the exclusion of the *first-pass reading time* of that region (Liversedge, Paterson, & Pickering, 1998). The re-reading time measure thus reflects the time spent on re-reading earlier portions of the text. Interestingly, the *regression path duration* and the *re-reading time* attribute the time spent in second pass to the processing of the region where the second pass started and not to the processing of the regions that are re-read.

Two remarks should be made here. Firstly, what is obvious from this summary is that not one measure of processing time stands out as the best. All measures reflect only certain aspects of reading behaviour and the question which one(s) to use depends on the research question at hand. Secondly, the measures listed here are the most prominent measures of processing time used nowadays in eye-movement reading research, but the list is not complete. These measures, albeit well established and often used, are still subject to investigation themselves (e.g., Inhoff & Radach, 1998). The complexity of eye-movement behaviour during reading is not completely understood, nor is there absolute certainty about the relation between the spatial and the temporal aspects of eye-movement behaviour and cognitive processes. The field is clearly still developing. As Rayner (1998, p. 372) puts it, we are now in "the third era of eye movement research", suggesting (many) more to come.

The measures reported above are not without their problems. Two of these problems will be addressed here. The first problem concerns the way in which first-pass measures, be it *first fixations*, *gaze durations* or *first-pass reading times*, treat observations prior to a regression; the second concerns the fact that none of these measures includes saccade durations.

5.2 First-pass forward reading times

The *gaze duration* measure as explained above is calculated for each word starting with the first forward fixation on a word and ending with the last fixation on that word before the eyes are moved to another word. The *first-fixation durations* and the *first-pass reading times* are calculated in an analogous way. What these measures are assumed to represent is the ongoing (first-pass) continuous processing of a region. By definition, it is implied that the nature of the consecutive observation is of no consequence to its measurement. In other words, it is of no consequence whether the next fixation is situated in the same, the following, or the preceding part of the text. This, however, seems very questionable. Altmann, Garnham, and Dennis (1992) introduced a *regression-contingent* analysis of first-pass reading times. In this analysis, first-pass reading times prior to a regression to an earlier part of the text are analysed separately from first-pass reading times prior to a forward saccade to the next region of the text.[1] Their data show that first-pass reading times prior to a regression are shorter than those prior to a forward movement.[2] An explanation for this difference would be that the decision to jump back in the text in order to resolve a comprehension problem occurs before the processing of that region is completed. This is indeed what is generally assumed to be the prime reason for making a regression: In order to resolve a comprehension problem, the reader decides to re-read an earlier portion of the text. If, on the other hand, the reader concludes the processing of a region (and solves the problem) while fixating that region, reading times on that region will be longer. Although regressions normally are attributed to comprehension difficulties (Rayner, 1998; Rayner & Pollatsek, 1989; Rayner et al., 1989, and others), it is not the case that if a comprehension difficulty is encountered, a regression is made (see also Rayner & Sereno, 1994c; Rayner & Sereno, 1994b). Frazier and Rayner (1982) observed three distinct patterns of eye movements when readers encountered a parsing problem during comprehension: (1) They made a regression to the region of the text where the problem could be solved; (2) they continued reading in a forward direction but with long fixation durations; and (3) they continued reading until the end of the sentence with small saccades and long fixation durations, after which they regressed to the beginning of the sentence in order to re-read it. The conclusion from Altmann et al.'s (1992) and Frazier and Rayner's (1982) studies seems warranted that it is not sensible to calculate first-pass reading times without taking regressive behaviour into account. If readers encounter a comprehension problem and follow reading strategies (2) or (3), their first-pass reading times will be longer, and if they follow reading strategy (1), their reading times will be shorter.

To substantiate the findings of Altmann et al., an analysis was performed of the first-fixation durations of the critical regions of the target sentences in Experiment 6. To recapitulate, Experiment 6 set out to investigate the influence of the presence of the connective *because* on the

[1] Note that this definition of regressions does not include cases where the reader makes a corrective backward movement within the same region of the text.

[2] This is not what Altmann et al. (1992) explicitly stated but can be deduced from their data.

comprehension of causal relations. The results showed that the connective influenced the comprehension of the causal relation in two ways. Firstly, it had a facilitative effect on the processing of the immediately following words, which constituted the cause for the causal relation. This facilitation is attributed to the process of integrating the words in the overall sentence structure. Secondly, it elicited an inference about the content of the relation, dependent on the reader's knowledge. The inferential process produced an increase in processing time of the final words of the clause. The causal relation sentences were divided into regions of one or more words:

He experienced a big/ delay,/ because/ there/ was a speed check/ on the highway.

The critical region for the integration effect was *was a speed check* (called the middle region), and the critical region for the inference effect was *on the highway* (called the final region). The first-fixation durations of these regions were entered into the analyses.

The decision to jump back in the text is often taken early during processing. It is not surprising, therefore, to find that many regressions occur immediately after the first fixation in a region. In fact, as can be seen in Table 5.1, which presents the frequency of fixations in the critical regions, most regressions occurred directly after the first fixation. Regressions after first fixations accounted for approximately 74% of the regressions.

The first-fixation durations that were entered into the analyses were the first fixations belonging to the cases where the next fixation fell in the same or in the next region (the first and third rows in Table 5.1), and the first fixations from which the reader immediately regressed to an earlier region (the first cells of the second and fourth rows in Table 5.1). The analyses of variance were similar to those reported in Chapter 4 (see Section 4.2.2). Cases on which an error was made in the verification task (5.7%) were excluded from the analyses, as were blinks (overall 0.1%). There were 1.0% missing cases but no outliers exceeding 2.0 *SD* from the participants and items means within condition. Analyses were conducted per critical region and over the two critical regions combined. The factor position of the Next fixation (in the same/next region versus in an earlier region) was analysed

Table 5.1: Frequency of fixations in the critical regions of the causal relation sentence as a function of Next fixation: in the same or in a subsequent region versus in an earlier region (data, collapsed over the factor Familiarity, from Experiment 6)

		Number of fixations								
Region	Next fixation	1	2	3	4	5	6	7	8	9
middle	same/next	50	311	256	90	32	13	5	3	1
	earlier	109	14	3	2	3				
final	same/next	252	369	93	17	2	2			
	earlier	94	37	10	2					

between participants (F_1) and between items (F_2)[3]. In the combined analyses, the factor Region was a within participants and within items factor. It was expected that the first-fixation durations prior to a regression would be shorter than those prior to a forward eye movement. Table 5.2 presents the mean first-pass first-fixation durations.

Table 5.2: Mean first-pass first-fixation durations (ms) of the two critical regions of the causal construction, middle and final, as a function of Next fixation (percentage of valid cases from the total number of possible cases per region in superscript; data, collapsed over the factor Familiarity, from Experiment 6)

	Region	
Next fixation	middle	final
same/next region	$216^{82.2\%}$	$219^{82.8\%}$
earlier region	$194^{11.6\%}$	$202^{9.9\%}$

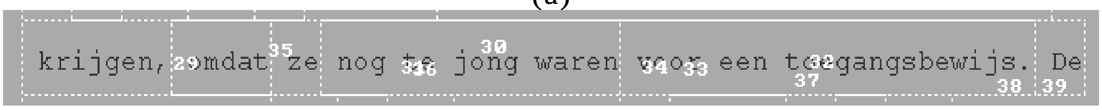
The analysis of the middle region showed an effect of Next fixation:

[3]Due to the small number of regressions, the factor position of the Next fixation was not analysed within participants or items.

$F_1(1,65) = 3.39$, $MSE = 2349$, $p < 0.05$ (one-tailed); $F_2(1,38) = 20.00$, $MSE = 453$, $p < 0.001$. The first-fixation durations prior to a regression were shorter than those prior to a forward saccade. In the analysis of the final region, too, fixation durations prior to a regression were shorter than those prior to a forward saccade: $F_1(1,67)= 4.45$, $MSE = 1259$, $p < 0.05$; $F_2(1,40) = 5.60$, $MSE = 904$, $p < 0.05$. The combined analyses of the two regions also revealed a significant effect of Next fixation: $F_1(1,132) = 7.51$, $MSE = 1796$, $p < 0.01$; $F_2(1,78) = 20.29$, $MSE = 685$, $p < 0.001$. Again, fixation durations followed by a backward saccade were shorter than those followed by a forward saccade. There was no effect of Region, nor was there an interaction (Fs < 1).

The analyses showed that the durations of the first fixations were influenced by the type of continuation. The analyses supported the hypothesis that if a fixation is followed by a backward saccade, that is, a regression to an earlier portion of the text, its duration is shorter than if it is followed by a forward saccade. The results were in line with those of Altmann et al. (1992).

(a)



(b)

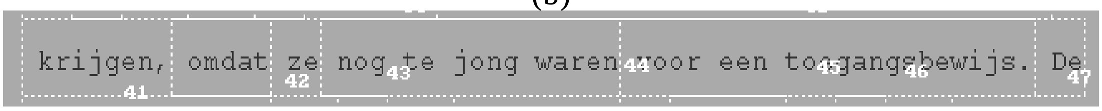


Figure 5.1: Eye-movement data of the reading of a target sentence by two participants in Experiment 6. In example (a), a regression was made in the final region (*voor een toegangsbewijs*) starting with fixation number 32, whereas in example (b) no regression was made. In example (a), fixations run from 29 to 39 and in example (b), from 41 to 47. [Literal translation: *to get, because they still too young were for a ticket. The*]

The effect of regressive eye movements on the first-fixation durations, as shown here, is a special case of the general effect regressions have on first-pass reading times. In general, the first-pass reading times will be shorter if the processing of a region ends with a regression than if it ends with a forward saccade. This is illustrated in Figure 5.1, showing two readings of the second part of a target sentence, the first of which contains a regression in the final region.

As can be seen in Table 5.3, the first-pass reading times of the final regions of (a) and (b) add up to 685 ms and 730 ms, respectively. However, the fixation durations that added up to the first-pass reading time of the final region of example sentence (a) (fixations 32 to 34) did not seem to reflect the complete processing of that region. It is conceivable that fixations 35 through 38 also contributed to the processing time of the final region, for only after fixation 38 did the reader continue with the next region. The fixation durations of the same region in example sentence (b) (fixations 44 to 46), on the other hand, did seem to reflect the complete processing of that region. With fixation 46, the processing of the region seemed to be concluded, since the reader continued with the next region. What this example illustrates is that if regressions occur, first-pass reading times are prone to be underestimations of the actual processing time of a region.

Table 5.3: Durations of the fixations (ms) in the final region (*voor een toegangsbewijs*) of the two example sentences in Figure 5.1.

example (a)		example (b)	
fixation nr	duration	fixation nr	duration
32	240	44	235
33	275	45	235
34	170	46	260
$\sum$	685		730

The extent of the influence of the inclusion of reading times before regressions in the first-pass reading times depends on the number of regressions made. The larger the number of regressions are, the more strongly affected are first-pass reading times. As mentioned above, regressions often occur when the reader encounters a difficulty during comprehension. This characteristic of reading behaviour has been used to compare experimental conditions in which a processing difficulty was expected to occur with conditions in which this would not be the case. Obviously, the first-pass reading times in the difficult condition in which more regressions are made suffer a larger reduction in reading time than those in the easy condition in which fewer regressions are made. Paradoxically, this might even lead to the situation that shorter average first-pass reading times are found in the difficult condition compared to the easy condition (Konieczny, 1996, p. 65).

It is striking to see that this phenomenon has been observed and noticed before (Altmann et al., 1992), but that generally it has not led to an adjustment of the computation of first-pass measures of reading time (Rayner, 1998; Rayner & Sereno, 1994c). There are several other measures of reading time, however, to which this specific problem does not apply. As mentioned before, Altmann et al. (1992) introduced a *regression-contingent analysis*, in which first-pass reading times belonging to observations prior to a regression were analysed separately from those belonging to observations prior to a forward continuation of reading. Konieczny et al. (1995) suggested a different approach. In addition to first-pass reading times, they proposed using *regression path durations*: sums of fixations on a region including all regressive fixations made from that region into earlier regions until the region has been left in a forward direction. The regression path duration is an altogether different measure. First-pass reading times only include fixations belonging to a particular region until that region is left in a forward or backward direction. The regression path duration of a region, on the other hand, attributes all regressive fixations to the processing of the region in which the regression started. A variant of this measure has also been used in Experiment 6 (see Section 4.3.2). Both the regression-contingent analysis and the regression path durations were used in studies on syntactic processing where processing difficulties were elicited by means of garden-pathing. It stands to reason that regressions played an important role in these studies: Garden-pathing was directly related to their frequency of occurrence.

As mentioned earlier, however, in normal reading circumstances, regressions only occur in 10 to 15% of the cases. Their occurrence might be informative but in most studies the researcher's attention is directed to first-pass reading time measures which purportedly reflect the immediate processing of text. The analyses of first-fixation durations reported above, as well as the data of the Altmann et al. (1992) study, suggested that these measures will be distorted if regressive behaviour is not taken into account. The distortion will be greater, as the difference in the occurrence of regressions between experimental conditions is greater. Therefore, if cases in which a regression is made are excluded from the analysis of first-pass reading times, the first-pass reading times will give a clearer picture of the immediate, undisrupted processing of text. Since the exclusion of regressions from this measure results in only those observations where the reader progresses through the text, the term first-pass *forward reading times* seems appropriate. This measure was used in Experiment 6.

To illustrate the point that the inclusion of observations prior to a regression affects the calculation of first-pass reading times, analyses were conducted of the first-pass reading times of the two critical regions in Experiment 6. The occurrence of regressions in the middle and the final regions of the sentence was not equally balanced over conditions (see Table 5.4).

Table 5.4: Percentage of regressions in the two critical regions (middle and final) of the causal relation as a function of Connective (data, collapsed over the factor Familiarity, from Experiment 6).

	Region	
Connective	middle	final
present	12.9	17.5
absent	14.6	12.5

In the middle region, there seemed to be more regressions when the connective was absent compared to when it was present; in the final region, it seemed to be the other way around. The regression patterns revealed only a tendency for the final region: $\chi^2 = 3.79$, $df = 1$, $p = 0.052$.

The mean first-pass reading times were analysed in exactly the same way and with the same factors as the first-pass forward reading times (see Section 3.3.2). Reading times belonging to items on which the participants had made a verification error (5.7% of the data), as well as outliers exceeding 2.0 *SD* based on participants and item means within condition, were excluded from the analysis (0.05% on average). There were several missing data as a result of skipping or blinks (0.9% on average).

Table 5.5 shows the mean first-pass reading times. As can be seen at first glance, the means were lower than their corresponding mean first-pass forward reading times in Table 4.5.

Table 5.5: Mean first-pass reading times[a] (ms) of the two critical regions (middle and final) of the causal relation as a function of Familiarity and Connective (data from Experiment 6).

		Region	
Familiarity	Connective	middle	final
very familiar	present	545	390
	absent	591	359
not very familiar	present	552	413
	absent	609	406
% cases forward		79.3	76.6
% cases backward		13.8	15.0

[a] Without taking regressive behaviour into account.

The results were in line with the results of the analyses of the first-pass forward reading times, but not quite as conclusive. The middle region of the sentence was processed faster if the connective was present: $F_1(1,36) = 4.91$, $MSE = 21269$, $p < 0.05$; $F_2(1,20) = 5.21$, $MSE = 14243$, $p < 0.05$. The factor Familiarity showed no effect on the processing of this region, nor was there an interaction of this factor with Connective. The final region showed an effect of Connective only in the analysis by participants: $F_1(1,36) = 4.64$, $MSE = 3083$, $p < 0.05$; $F_2(1,20) = 1.39$, $MSE = 5776$, $p > 0.1$. According to the participants analysis, this region was processed faster if the connective was absent than if it was present. Reading times for familiar items were shorter than for less familiar items: $F_1(1,36) = 9.73$, $MSE = 5022$, $p < 0.01$; $F_2(1,20) = 3.69$, $MSE = 8687$, $p < 0.05$ (one-tailed). No other effects were found for this region. An analysis in which the data of the two regions were entered together showed a significant interaction between the factors Region and Connective: $F_1(1,36) = 9.66$, $MSE = 10140$, $p < 0.01$; $F_2(1,20) = 5.26$, $MSE = 12470$, $p < 0.05$. No main effect of Connective was found in this analysis and Familiarity was significant in the participants analysis only: $F_1(1,36) = 5.18$, $MSE = 8612$, $p < 0.05$; $F_2(1,20) = 1.67$, $p > 0.1$.

In comparison with the first-pass forward reading times, the results were less convincing. It seems as if the differences between the conditions were reduced. The difference between the conditions with and without connective (collapsed over the factor familiarity) in the middle region was 51.5 ms for the first-pass reading times compared to 58 ms for the first-pass forward reading times. In the final region, these differences were 19 ms and 33.5 ms, respectively. This reduction could be ascribed to the inclusion of observations prior to a regression in the analyses. Although marginally significant, the unbalanced distribution of regressions over the conditions apparently did result in a distortion of the first-pass reading times.

Conclusion

The inclusion of observations prior to a regression in the computation of first-pass reading times leads to an underestimation of these times. When running into comprehension difficulties, the reader essentially can choose between two strategies, read on or jump back (but see above). If the first strategy is followed, the problem is solved during the processing of the same or the following regions of the text. If the second strategy is followed, the problem is solved during the processing of earlier regions of the text. So far, it is unclear what the factors governing this decision are. However, if the decision is made to jump back, it can be concluded that the processing of that region is not complete. This same conclusion, however, cannot be drawn if the reader decides to read on. Therefore, when using first-pass reading times to analyse the processing of a region, one risks the introduction of an error if cases where processing is incomplete, are included.

5.3 The inclusion of saccades

The second problem referred to in the introduction is whether saccade durations should be included in the calculation of measures of reading time. Aggregational measures of processing time based on eye movement recordings usually sum only the fixation durations on words or regions. This procedure originated from Just and Carpenter (1980). They calculated the sum of the fixations on a word and termed this measure *gaze duration*. ”By examining where a reader pauses, it is possible to learn about the comprehension processes themselves” (Just & Carpenter, 1980, p. 329). What is implied by this assumption is that the time a reader spends on making saccades is not relevant to the study of comprehension processes. No further justification for this restriction on the calculation of reading times was given, and, surprisingly, the restriction has not been questioned until recently (Irwin, 1998). Of course, one could argue that if gaze durations are used as a measure of reading time, saccade durations play an insignificant role since re-fixations on words within the same pass occur only seldom. However, this argument does not apply to aggregational measures of reading time that span a larger region than a single word. Larger regions normally are fixated more than once, which results in many intermediate saccades (see for instance Table 5.1).

Before going into the question whether or not to include saccade durations in measures of reading time, a closer look is taken at what is known about eye movements and cognitive processing during reading. Basic to the eye-movement reading research paradigm is the well-established fact that visual information is acquired during a fixation when the eyes are relatively still. During a saccade, when the eyes move with a velocity of up to 500 degrees per second, no visual information is acquired, a phenomenon called saccadic suppression. The acuity of the eyes is sharpest at the centre of vision, an area called the fovea, which extends 1 degree of visual angle to the left and right of fixation (1 degree is the equivalent of 4 to 5 characters in normal reading circumstances). At the parafovea, which is the area extending 5 degrees of visual angle on either side of the fixation point, visual acuity drops markedly but allows some information to be obtained. The rest of the visual field is called the periphery, an area that plays no role in reading. The purpose of the eye-guidance system during reading is to bring the foveal area to that part of the text that has to be processed next. It is believed that there are two separate processes involved in the control of eye movements: one process that determines *where* to move the eyes and one process that determines *when* to move the eyes. These processes are believed to be largely independent of each other. A good deal of research aims to disentangle them and to develop a model of eye-movement control (for a general framework, see Findlay & Walker, 1999).

The process *where* to move the eyes is related to saccades. Saccades are ballistic, autonomous eye movements with durations varying as a function of their length. The average saccade in normal reading extends 8 to 9 character spaces, i.e., 2 degrees of visual angle, and on average lasts 30 milliseconds. The decision where to move the eyes is governed by low-level perceptual and oculomotor factors as well as by higher-level cognitive factors. Low-level factors that influence the decision *where* to look next, that is, how large the next saccade should be, are the length of the words on the right of fixation (long words tend to be fixated, short words tend to be skipped), the preference for a landing position (most saccades end at what is called the preferred viewing position, a position somewhat to the left of the centre of the fixated word), and the position from which the saccade is launched (a launch site far from the target tends to produce an undershoot; a launch site close to the target tends to produce an overshoot). Crucial to these factors is that they are based on information that is extracted from parafoveal preview. It is a matter of debate how much and what kind of information, perceptual or cognitive, can be extracted from parafoveal preview and how this information influences saccade calculation (for a recent discussion, see Vonk, Radach, & van Rijn, 2000). Higher-level cognitive factors are assumed to determine the direction of the next saccade. The difficulty of a word or a text influences the decision to stay at the present word, jump back in the text, or to move on to the next word.

The process determining *when* to move the eyes is related to fixations. Fixation durations have been shown to be influenced by low-level factors as well as by higher-level factors. A low-level factor influencing the duration of a fixation is the time it takes to calculate a saccade, the so-called saccade latency. This calculation is believed to take 150 milliseconds on average. Only when the next saccade has been calculated will the eyes be able to make a move. A second low-level factor is the time needed for intake of visual information. If readers are deprived of visual input below a period of 50 milliseconds, reading becomes disrupted. Apparently, beyond this period enough visual information is acquired to sustain normal processing.

There is abundant evidence for cognitive influences on fixation durations. Several lexical, syntactic, and discourse factors influence fixation time on a word, for instance, word frequency, contextual constraint, semantic relationships between words, anaphora and co-reference, lexical ambiguity, and syntactic disambiguation (for an overview, see Rayner, 1995). This list can be extended with many more factors, amongst which are such higher-order comprehension processes as sentence or clause wrap-up, sentence integration processes, and inferential processes (see, for example, Experiment 6, Chapter 4).

The relationship between the duration of a fixation on a word and the cognitive processing of that word is not perfect. Spill-over effects and parafoveal preview effects undermine the *eye-mind* and the *immediacy of processing* assumptions made by Just and Carpenter (1980). What this means is that there is no perfect match between the duration of the fixation on a word and the processing of that word. Some processing time might be attributable to the processing of a word other than the word fixated.

The current state of affairs in the eye-movement reading research gives good grounds to believe that fixation durations are effective indicators of comprehension processes. The same conclusion cannot so easily be drawn with respect to saccade durations. Saccade length, and consequently, saccade durations are not under the control of higher-level cognitive processes but are determined solely by low-level perceptual processes (however, see Vonk et al., 2000). This characteristic together with the fact that no visual information is acquired during a saccade has led to the conclusion that saccade durations do not reflect comprehension time during reading. However, what is implicitly ignored in this reasoning is the possibility that cognitive processing continues during a saccade and that the duration of a saccade therefore amounts to comprehension time. This possibility has been investigated by Irwin (1998).

As Irwin (1998) pointed out, the idea that cognitive processing is suppressed during a saccade may seem very implausible. ”Even though saccade durations are very brief, the cumulative effect of cognitive suppression during saccades could be quite large; if one assumes that the average person makes 2-3 saccades each second (hence, 115,200 to 172,800 per 16-hour waking day) and that the average saccade lasts about 30 ms, then cognition would be disrupted for a total of 60-90 minutes a day!” (Irwin, 1998, p. 2). However unlikely (complete) saccadic suppression may seem, it is still conceivable that at least some cognitive processing is disrupted. In the past two decades, several studies have investigated whether saccades interfere with cognitive processing. Irwin presented an overview. In 1985, Sanders and Houtmans obtained evidence for saccadic suppression on the processing of a visually degraded stimulus in a same/different matching task. The processing of the degraded stimulus was found to be interrupted by a saccade. In 1993, Matin, Shao, and Boff found a cost in information processing time when participants had to execute saccades during a visual digit-counting task. In 1996, Irwin and Carlson-Radvansky showed that the execution of saccades interferes with the process of mental rotation. Other cognitive processes do not seem to be disturbed by the participant having to perform a saccadic eye movement. For instance, response selection and priming seem to continue while the eyes are in motion. Relevant to the current discussion is the finding of Irwin that lexical decision and word identification processes are not affected by saccades. These lexical processes continue uninterruptedly. Of course, this finding has implications for the measurement of reading processes. If these lexical processes continue during saccades, saccade duration should be included in measures of reading time.

Irwin hypothesises that saccadic suppression might be the result of dual-task interference. According to this hypothesis, suppression of cognitive processing during saccades should only occur when shared processing structures are called upon. Any cognitive process that shares processing resources with saccadic programming, saccade execution, or visual processing should be affected. This applies to such visual processes as same/different matching of visual stimuli or mental rotation, but not to lexical processing, since it contains non-visual components which do not overlap with these processes. Lexical processing should, therefore, not be suppressed during saccades.

What is the effect of the inclusion of saccade durations?

If saccade durations do matter with respect to the measurement of reading times, the question is to what extent. Obviously, if one investigates comprehension processes using small regions like words, the effect of the inclusion of saccade durations in the calculation of reading times will be relatively small, for such small regions are often fixated only once. On the other hand, if reading times are obtained by aggregating fixation durations over large(r) regions, the effect of saccade inclusion will be relatively large. Furthermore, the number of fixations and consequently the number of saccades is often directly related to the difficulty of the textual material. The more difficult a text is, the more often it will be fixated.

Table 5.6: Number of fixations and total number of within-saccades in the middle region and the final region of the causal relation sentence as a function of Connective (data, collapsed over the factor Familiarity, from the first-pass forward reading times in Experiment 6).

		number of fixations									within-saccades
Region	Connective	1	2	3	4	5	6	7	8	9	$\sum$
middle	present	40	176	111	39	10	8	2	1	1	622
	absent	10	135	145	51	22	5	3	2		723
final	present	109	185	53	9	1	1				327
	absent	143	184	40	8	1	1				297

Take, for instance, the distribution of fixations in the critical regions of the causal relation in Experiment 6, Chapter 4. It was concluded in section 4.4 that the middle region of the causal relation (for an example, see page 87) is more difficult to process if the connective *because* is absent and the processing of the final region is more elaborate if the connective is present.

As can be seen in Table 5.6, there was indeed a shift to more fixations and consequently more within-saccades[4] in the middle region if the connective was absent and in the final region if the connective was present.

The frequency counts of fixations and their intermediate saccades suggested that there were differences in summed saccade durations between conditions as well. Table 5.7 shows the mean summed within-saccade durations of the first-pass forward reading times of Experiment 6 in the critical regions of the causal relation as a function of the familiarity of the causal relation and the presence of the connective *because*. The mean summed within-saccade durations were distributed over conditions in the same way as the reading times (cf. Table 4.5), but the similarity was not perfect.

Table 5.7: Mean summed within-saccade durations (ms) in the two critical regions (middle and final) of the causal relation as a function of Familiarity and Connective (data from the first-pass *forward reading times* in Experiment 6).

		Region	
Familiarity	Connective	middle	final
very familiar	present	61	41
	absent	60	35
not very familiar	present	59	39
	absent	67	41

Analyses were performed to see whether the mean summed within-saccade durations produced reliable effects of the presence of the connective *because*. The data were submitted to analyses of variance similar to those of the first-pass forward reading times (see Section 4.3.2). For the middle region, there was an effect of Connective *because* in the analysis by items but not in the analysis by participants: $F_1(1,35) = 2.53$, $MSE = 312$, $p = 0.12$; $F_2(1,20) = 7.42$, $MSE = 143$, $p < 0.05$. The mean summed within-saccade durations were shorter if the connective was present. There was a trend for an interaction between the factors Familiarity and Connective

[4]Within-saccades are the intermediate saccades between the consecutive fixations in a region.

in the analysis by participants but not in the analysis by items: $F_1(1,35) = 3.72$, $MSE = 218$, $p = 0.062$; $F_2(1,20) < 1$. The analyses of the final region showed no effects. An analysis of the two regions combined showed an interaction between the factors Region and Connective in the analysis by items only: $F_1(1,31) = 2.63$, $MSE = 283$, $p = 0.115$; $F_2(1,20) = 5.40$, $MSE = 166$, $p < 0.05$. In this analysis, there was a trend for an interaction between Familiarity and Connective: $F_1(1,31) = 4.09$, $MSE = 177$, $p = 0.052$; $F_2(1,20) = 3.70$, $MSE = 125$, $p = 0.069$. Clearly, the differences between the mean summed within-saccade durations of the first-pass forward reading times were in the right direction but not strong enough to produce reliable effects of the presence of the connective. The same analyses were conducted on the summed within-saccade durations of the reading times resulting from the first-pass regression path analyses (see Table 4.7). The mean summed within-saccade durations are given in Table 5.8.

Table 5.8: Mean summed within-saccade durations (ms) in the two critical regions (middle and final) of the causal relation as a function of Familiarity and Connective (data from the first-pass *regression path durations* in Experiment 6).

		Region	
Familiarity	Connective	middle	final
very familiar	present	67	53
	absent	70	48
not very familiar	present	71	64
	absent	84	55

The analyses of the middle region revealed a significant effect of Connective. Mean summed within-saccade durations were shorter if the connective was present: $F_1(1,36) = 6.37$, $MSE = 426$, $p < 0.05$; $F_2(1,20) = 9.83$, $MSE = 169$, $p < 0.01$. There also was an effect of the factor Familiarity. Mean summed within-saccade durations were shorter if the causal relation was very familiar: $F_1(1,36) = 7.92$, $MSE = 436$, $p < 0.01$; $F_2(1,20) = 2.99$, $MSE = 533$, $p < 0.05$ (one-tailed). No other effects were found. The analysis of the final region of the causal relation revealed an effect of

Connective: $F_1(1,35) = 3.19$, $MSE = 642$, $p < 0.05$ (one-tailed); $F_2(1,20) = 3.60$, $MSE = 292$, $p < 0.05$ (one-tailed). If the connective was present, the mean summed within-saccade durations were longer. The factor Familiarity was significant, too: $F_1(1,35) = 5.79$, $MSE = 517$, $p < 0.05$; $F_2(1,20) = 3.99$, $MSE = 643$, $p < 0.05$ (one-tailed). Mean summed within-saccade durations were shorter in the condition with very familiar causal relations. No other effects were found. Finally, there was no effect of Connective in the combined analyses of the middle and the final region, but the interaction between Region and Connective was significant: $F_1(1,35) = 9.63$, $MSE = 476$, $p < 0.01$; $F_2(1,20) = 9.71$, $MSE = 276$, $p < 0.01$. Again, there was an effect of Familiarity: $F_1(1,35) = 14.71$, $MSE = 440$, $p < 0.01$; $F_2(1,20) = 6.79$, $MSE = 604$, $p < 0.05$.

The analyses of the summed within-saccade durations of the first-pass regression path durations of Experiment 6 showed that reliable effects of the presence of the connective can be obtained. These results are very much in line with those of the first-pass regression path durations themselves. It is safe to conclude that the durations of the within-saccades add up to comprehension time in the same way fixation durations do. The exclusion of saccade durations, therefore, leads to a systematic underestimation of comprehension time, and, as is the case in the present study, to a reduction of any effects attributable to manipulations of comprehension difficulty. Separate analyses of the first-pass forward reading times and the first-pass regression path durations did indeed show that the exclusion of within-saccade durations resulted in smaller differences between the means in the conditions with and without connective. For instance, in the analyses of the first-pass forward reading times without within-saccades in the middle region, the effect of the presence of the connective was 49 milliseconds as opposed to 58 milliseconds in the analysis where saccade durations were included. This smaller effect, however, was still significant: $F_1(1,36) = 6.81$, $MSE = 16032$, $p < 0.05$; $F_2(1,20) = 15.10$, $MSE = 7602$, $p < 0.01$.

The data presented above suggested that the effect of the connective found in the analyses of the within-saccade durations was a result of the differences in the number of within-saccades in the experimental conditions. It was unlikely that the effect had been brought about by the extent of the saccade durations themselves. If so, it would mean that saccade durations increased under the influence of textual difficulty, which is clearly in contradiction with all findings related to the nature of saccades (see the beginning of this section). Nevertheless, a closer look was taken at the mean saccade durations. Table 5.9 presents the mean saccade durations per experimental condition of observations with 2 fixations (1 within-saccade), 3 fixations (2 within-saccades), and 4 or more fixations (3 or more within-saccades).

Table 5.9: Mean within-saccade durations (ms) in the two critical regions of the causal relation sentence as a function of Number of saccades (1, 2, 3, or more), Familiarity, and Connective (data from the first-pass forward reading times in Experiment 6).

			Number of saccades			
Region	Familiarity	Connective	1	2	>= 3	overall
middle	very familiar	present	36	33	31	33.5
		absent	34	32	31	32.6
	not very familiar	present	35	33	31	34.1
		absent	35	33	31	33.2
final	very familiar	present	31	33	31	30.8
		absent	31	27	31	29.5
	not very familiar	present	32	30	29	31.2
		absent	30	29	29	30.3

Analyses of variance were performed on the mean within-saccade durations in the two critical regions of the causal relations. Surprisingly, the items analysis of the middle region showed an effect of Connective: $F_2(1,20) = 5.74$, $MSE = 4$, $p < 0.05$ (the participants analysis revealed no effects). However, the direction of the effect was opposite to that found in the analyses of the summed within-saccade durations: If the connective was present, the mean within-saccade duration was longer than if the connective was absent. No other effects were found, nor were there any effects in the analyses of the final region.

The effect found could be considered spurious, but an examination of the distribution of saccade durations invited another explanation. It seemed that the more saccades there were in a region, the shorter they were. This was in fact the case. There was a linear trend in the distribution of the mean within-saccade durations ranging from longer saccade durations if there were only few fixations to shorter saccade durations if there were many fixations. This trend was significant overall, $F(1{,}709) = 48.43$, $MSE = 42$, $p < 0.001$, and for each condition separately: familiar/with connective: $F(1{,}171) = 15.22$, $MSE = 43$, $p < 0.001$; familiar/without connective: $F(1{,}190) = 5.80$, $MSE = 43$, $p < 0.05$; not very familiar/with connective: $F(1{,}173) = 11.75$, $MSE = 45$, $p < 0.001$; not very familiar/without connective: $F(1{,}169) = 14.47$, $MSE = 38$, $p < 0.001$. This indicated that the phenomenon is independent of experimental condition and that the difficulty of the text has influence. Apparently, it is simply the case that if only a few fixations are made in a region, the fixations are further apart than if many fixations are made in the same region.

One issue remains to be addressed concerning the inclusion of saccades in the calculation of aggregational measures of reading time. What to do with saccades between regions? If one takes a region as starting point, saccades between regions can be divided into two types: those going into the region, from now on called *in-saccades*, and those going out of the region, called *out-saccades*. There are two problems associated with in-saccades and out-saccades. Firstly, it is hard to tell to what region of the text they belong. And secondly, their variability is quite great and cannot easily be controlled. Both problems will be dealt with below.

As explained above, the inclusion of within-saccades is justified because it has been shown that linguistic processing continues uninterruptedly during a saccade. Since both the source, the launching position, of the within-saccade and the target, the landing-position, of the within-saccade are known, the duration of the within-saccade can safely be assigned to the reading time of a region. Neither in-saccades nor out-saccades answer this description. In-saccades and out-saccades cannot easily be assigned to a specified region. Nevertheless, one could claim that at least in-saccades could be attributed to the region to which they are directed.

Extensive research on the nature of eye movements has shown that the calculation of saccades benefits from preview effects (Rayner & Pollatsek, 1989; Rayner, 1998). During a fixation, parafoveal information is extracted from the visual field in order to determine the size of the next saccade. If it is assumed that this means that the reader has already started processing the targeted region, it makes sense to attribute any processing occurring during the saccade to that region.

As a test of this claim, analyses were performed on the first-pass forward reading times of the middle and the final regions of the causal relation in Experiment 6 with the inclusion of in-saccades. The means of the Connective conditions (collapsed over the factor Familiarity) for the middle region were 643.5 ms for the within-, and 702 ms for the without-connective condition, respectively. For the final region, these means were 467 ms and 533.5 ms, respectively. If in-saccade durations contribute to the processing of the targeted region, their inclusion should lead to an enhancement of the effect already found. This was indeed the case. The effect of the presence of the connective was slightly more pronounced for both regions (for a comparison of these results see page 73). Middle region: $F_1(1,36) = 7.53$, $MSE = 19810$, $p < 0.05$; $F_2(1,20) = 16.11$, $MSE = 10311$, $p < 0.01$. Final region: $F_1(1,36) = 9.11$, $MSE = 4914$, $p < 0.01$; $F_2(1,20) = 3.08$, $MSE = 8936$, $p < 0.05$ (one-tailed).

However, unfortunately, things are not that simple. The length of the in-saccade and, consequently, its duration, are governed by basic low-level principles as well as, for instance, by the length of the targeted word. That is, the longer the targeted word, the longer the saccade to that word will be. A closer inspection of the middle region of the causal relation revealed that the words at the beginning of this region varied as a function of the presence of the connective. As it happens, in Dutch, word order changes from SVO to SOV in subordinate clauses. As a result of this change, the beginning of this region contained longer words if the connective was present than if it was absent. The effect of these longer words at the beginning of the region on the duration of the in-saccade can be observed by looking at the in-saccades originating from the region before the middle region. Table 5.10 shows the mean durations of the in-saccades originating from the region before the middle region together with the mean length of the word at the beginning of the middle region.

Table 5.10: Mean duration of in-saccades (ms) originating from the region prior to the middle region and the mean length of the word (characters) at the beginning of the middle region of the causal relation as a function of Familiarity and Connective (data from Experiment 6).

Familiarity	Connective	in-saccade	word length
very familiar	present	34.6	4.02
	absent	31.7	3.48
not very familiar	present	34.7	4.51
	absent	31.6	3.61

It is obvious that the mean durations of the in-saccades into the middle region were directly related to the length of the words at the beginning of the middle region. Although the data shown here represented only a subset of all in-saccades into the middle region, it shows convincingly that the inclusion of in-saccades in measures of reading time can only make sense if factors like word length are controlled for.

From the argument for the inclusion of in-saccades in the calculation of reading times it follows that out-saccades should not be assigned to the regions from which they originate. Out-saccades from one region are, of course, the in-saccades of the next region. They should be treated accordingly.

The second problem associated with in-saccades and out-saccades is their variability. If the origin of the in-saccade or the target of the out-saccade is not controlled for, their durations can vary substantially. One source of variation comes from return-sweeps during reading, the long jumps at the end of a line of text to the beginning of the next line. The launching position as well as the landing position of a return-sweep depend on several factors, some of which are difficult to control, for instance, reading strategy, reading proficiency, word length, word difficulty, et cetera.

The difference between a return-sweep and a regular saccade is considerable. As mentioned before, an average saccade lasts approximately 30 milliseconds. In comparison, a return-sweep can be as long as 80 milliseconds, depending on its size, of course. It is for this reason that the critical regions of the textual materials used in Experiment 6 were not situated near the end or the beginning of a line of text. The reading times of these regions were therefore not contaminated by return-sweeps.

Conclusion

The analyses of saccade durations presented here makes a case for their inclusion in aggregational measures of reading times based on eye movements. This applies to within-saccades, saccades that originate and end in the same region. This conclusion follows from studies that have shown that lexical processing is not interrupted during a saccade (e.g., Irwin, 1998), and, of course, from the separate analyses of within-saccades reported here, which produced effects similar to the analyses of the aggregational measures to which they belonged. Since the influence of the inclusion of within-saccades increases as their frequency of occurrence increases, within-saccade durations should not be omitted in aggregational measures of reading time based on eye movements.

A different conclusion is drawn with respect to saccades that enter or leave a region, i.e., in-saccades and out-saccades, respectively. The problems associated with these saccades warrant their exclusion from aggregational measures of reading time. Only if the factors governing their origin or their target, respectively, are well under the control of the experimenter, might their contribution to reading time be of value. In that case, it seems advisable to include in-saccades in the calculation of reading times of regions to which they are directed.

CHAPTER 6

Summary and conclusion

6.1 Summary

The present study aimed to investigate the influence of the reader's knowledge and the role of the causal connective *because* on the inferential processing of causal relations in the domain of general world knowledge.

As sketched out in Chapter 1, a central issue in the study of inferential processing is to determine under what circumstances inferences are made during reading. Studies on the processing of causal relations have shown that the reader's knowledge is an important determinant of when inferences are made on-line: Readers who are highly knowledgeable about the subject of a causal relation make a causal inference, whereas readers who have no knowledge whatsoever about the causal relation do not (Noordman & Vonk, 1992; Noordman et al., 1992; Simons, 1993). For instance, Simons (1993) compared the reading behaviour of economic experts with that of economic novices on the processing of causal relations in the knowledge domain of economics. He found that experts made a causal inference, whereas novices did not. The findings of these studies were based on reading experiments using causal relations that belonged to highly specific knowledge domains and that, in all but one experiment, were signalled by the causal connective *because*.

The present dissertation addresses two issues raised by these studies. The first issue is concerned with the role of the reader's knowledge in inferential processing and the second with the role of the causal connective *because*. The results of Simons' (1993) study suggest that knowledge is an all-or-nothing factor: Inferences are made if knowledge about the causal relation is available and they are not made if the knowledge is not available. But one may conceive of availability as a graded notion. Knowledge may be more or less available. That would imply that inferences are more or less probably made depending on the availability of the information. Therefore, the present study did not compare inferences about causal relations that are known with causal relations that are not known, but inferences about causal relations that vary in familiarity. The question is whether readers show a different inference behaviour for inferences concerning very familiar causal relations than for inferences concerning less familiar causal relations.

The second issue pertains to the role of the causal connective. In most of the studies on causal inferences, the causal relation was expressed by a causal connective. In one experiment (Simons, 1993, Exp. 8), inferences were made even in the absence of a causal connective. That was an experiment with highly knowledgeable readers. The question is whether the connective is necessary for inferences to be made during normal reading.

The level of the reader's familiarity with causal relations in the domain of general world knowledge was determined empirically in two experiments (Chapter 2). In the first experiment, the participants were asked to generate (highly plausible) causes for well-known everyday events embedded in short texts. The generated causes, embedded in their texts, were then presented to another group of participants to be judged on their plausibility (Experiment 2). The two experiments resulted in 24 texts on everyday topics in two versions: with a very familiar causal relation (highly plausible cause) and with a less familiar causal relation (less plausible cause). The causal relations were constructed as enthymemes, syllogistic chains of reasoning with a missing premise. The inference consisted of the missing (major) premise. For instance, in the sentence *John was delayed because he was in a traffic jam.*, which consists of the minor premise *he was in a traffic jam* and the conclusion *John was delayed*, the inference was the major premise *a traffic jam causes delay*.

In Chapter 3, two models were proposed regarding the influence of the reader's knowledge and the presence of the causal connective on the making of causal inferences. The first model assumes that the familiarity distinction resembles 'expert' versus 'novice' knowledge. According to this model, inferences will be made if the causal relation is very familiar independently of the presence of the connective. If the relation is not very familiar, no inferences will be made and, again, the connective will have no influence. The second model assumes that the two levels of familiarity reflect two levels of 'expert' knowledge. This model predicts inferences to be made in the very familiar condition regardless of the presence of the connective. In the less familiar condition, however, the connective is expected to make a difference, giving enough information to elicit the inference compared to when the connective is not present.

Two reading experiments were conducted to test these models. Experiment 3 contained three measures: probe recognition times, verification times, and reading times. Participants were presented with texts containing causal relations that varied in familiarity and in the presence of the causal connective *because*. They were instructed to read the texts, clause-by-clause, in a self-paced noncumulative moving window paradigm. During reading, a probe word was presented and participants had to decide whether it had occurred in the text. In the experimental texts, the probe word originated from the first clause of the causal relation and was presented after the reading of the second clause. If the inference is made, the reader connects the second clause to the first and, consequently, reactivates the first clause in memory. The probe recognition times reflect the activation level of the probe word in memory, giving evidence of whether the inference has been made. After reading the text, participants had to judge a verification sentence which contained the inferential information. If the inference is made, verification of this information is relatively easy, for the inferential information is then readily available. The reading times, finally, give evidence for inferential processing by showing an increase, because inferences are time-consuming. The focus in this experiment was on the main effect of familiarity and on the interaction between familiarity and the presence of the connective. There was a restriction to the interpretation of the results of the verification times and the reading times. Because the two familiarity conditions of the reading and the verification tasks were expressed by different sentences, main effects of familiarity on these measures did not allow for a conclusion about inferencing. Together, the three measures were expected to give evidence for inferential processing.

The results did not support either model of inferential processing. The verification times showed an effect of the connective in both familiarity conditions: The verification times were shorter if the connective was present. Furthermore, verification times were shorter in the very familiar condition than in the less familiar condition. The probe recognition task revealed shorter recognition times when the connective was present than when it was absent for the very familiar causal relations only. There was no main effect of familiarity. The reading times showed an effect of familiarity: Familiar clauses were read faster than less familiar clauses. The results of the verification task and, partly, the results of the probe recognition task suggested that inferences were made if the connective was present. This was not predicted by either model of inferential processing. The expert-novice model predicted a main effect of familiarity in the probe recognition times and no effect of the connective nor an interaction on either measure. The two levels of 'expert' knowledge model predicted an interaction between connective and familiarity on all three measures, caused by an effect of the connective for the less familiar causal relations only. However, no interactions were found in the reading times and the verification times, and the probe recognition times showed exactly the opposite effect.

Given that the verification times of Experiment 3 reflected inferential processing depending on the presence of the connective, it was puzzling not to find this effect on the probe recognition task or on the reading task. Experiment 4 was set up to test whether, by reducing the complexity of the experiment and by increasing the familiarity of the causal relations, the sensitivity of the probe recognition task could be improved. The reading task of Experiment 4 was similar to that of Experiment 3, but the verification task was moved to the end of the experiment and sentences were inserted before the causal relations that enhanced their familiarity. The results of the probe recognition task, this time, corroborated the results of the verification task in Experiment 3. There was a main effect of the connective: The probe recognition times were shorter if the connective was present.

Taken together, the experiments supported the assumption that inferences were made if the connective was present. Furthermore, evidence for inferencing was found in both familiarity conditions: Inferences were made independently of the familiarity of the causal relation. However, evidence for inferencing was obtained in the verification times and the probe recognition times only; the reading times did not show this effect. An important characteristic of the reading task used in both experiments was that reading times were measured clause-by-clause. The reading times, therefore, reflected the processing of complete clauses. The fact that no increase in reading times was found when the connective was present was attributed to two functions of the causal connective *because*, which each have a different effect on the reading times. On the one hand, the connective elicits the making of an inference, which results in longer reading times. On the other hand, the connective signals how the clauses should be integrated. To the reader, the integration function indicates the way in which the clause has to be integrated with the previous text. The connective *because* signals to the reader that a causal coherence relation between the clauses has to be established. There is evidence in the literature that the integration function speeds up processing (Haberlandt, 1982; Millis et al., 1995; Millis & Just, 1994; Sanders & Noordman, 2000). The absence of an effect of the connective on the clause reading times, therefore, might be explained by the cancelling out of these two processes.

In Chapter 4, a closer look was taken at the reading times. Two experiments were reported that tested the hypothesis about the two functions of the connective *because*. Experiment 5 used the same self-paced noncumulative reading technique as the previous experiments, but the size of the moving window was reduced to one or more words. Presenting the texts in small units made it possible to measure the reading times on parts of the sentence. It was expected that the effects of the two functions of the connective would show at different locations during the processing of the second clauses of the causal relations. Since integration is expected to take place during the processing of the words in the sentence and the inference is expected to be made after the complete sentence has been processed, it was expected that the reading times of the words immediately following the connective would show a speeding-up effect and the last words of the sentence a slowing-down effect. The results of the reading times analyses did indeed support these expectations. The words immediately following the connective were read faster and the words at the end of the sentence were processed more slowly if the connective was present. Furthermore, the analyses of the verification times replicated the results of Experiment 3. Verifications were judged faster if the connective was present.

Experiment 6 replicated the reading times results of Experiment 5 in a reading paradigm that more closely resembles how people normally read. By using the eye-movement registration technique, readers were allowed to read the texts in their entirety, looking back if necessary, and they were not required to press a button during reading. The reading times were computed for parts of the text by aggregating the durations of the consecutive fixations and their intermediate saccades. Two types of reading time measures were used: the first-pass forward reading times and the first-pass regression path durations. The analyses of both types of reading time measures supported the findings of Experiment 5. They revealed a facilitative effect of the connective on the reading of the words immediately following the connective and a slowing-down effect on the sentence-final words.

Two methodological issues related to the reading time measures used in Experiment 6 were discussed in Chapter 5. The first issue concerns regressions, i.e., eye movements that are directed backward in the text. It was explained that because regressions are considered to be indicative of processing difficulties, reflecting the decision of the reader to re-read an earlier portion of the text in order to solve a problem, and because the reading times immediately preceding a regression are relatively short, the inclusion of cases in which a regression is made in aggregated measures of first-pass reading times of words or regions of the text would result in an underestimation of the actual processing time associated with these words or regions. It was suggested, therefore, that cases in which the reader makes a regression should be excluded from the calculation of the aggregated first-pass reading times of that word or region. The resulting reading time measure was coined *forward reading time*. To study reading behaviour that is related to regressions, one should rely on other measures (see Section 5.1).

The second issue concerns the role of saccades in the calculation of reading times from eye-movement recordings. The mainstream studies in eye-movement reading research employ the method of adding up consecutive fixations on words or regions of words in order to obtain aggregated measures of reading time. The durations of the saccades interspersing the consecutive fixations are not included. It was claimed that this is not correct. In support of Irwin's (1998) finding that lexical processing continues unperturbed during the making of a saccade, it was shown in separate analyses that aggregated saccade durations produced the same results as the reading time measures used in Experiment 6. Furthermore, analyses of the aggregated measures of reading times used in Experiment 6 in which saccade durations were included showed stronger effects than the comparable analyses in which saccades were excluded. It was concluded, therefore, that saccade durations contribute to reading time in a similar way as fixation durations and that they should be included in aggregated measures of reading time.

6.2 Conclusion

Conclusions from this study concern the methods of reading research employed in the present study, the influence of the availability of knowledge on inferential processing, the role of the connective *because* in the processing of causal relations, and the processes of integration and inference.

Method. Two experimental reading research methods were used in the present study: the self-paced noncumulative moving window method (Experiments 3, 4, and 5) and the eye-movement registration technique (Experiment 6). The self-paced reading paradigm is simple, easy to apply, and does not impose any constraints on the participants or on the equipment. It has some shortcomings, however. First, the method requires participants to press a button each time a part of the text is read. This causes reading times to be contaminated with motor response times that are unrelated to the reading process itself. Second, the requirement of having to press a button might cause spill-over effects. If the button is pressed prematurely, processing difficulties on one part of the text might show on the next part (see, for example, Experiment 5, region 7). Third, participants cannot look back in the text. If they encounter a reading problem, they pause on the part that is visible. Looking back during reading, however, is a rather common reading behaviour. The method, therefore, forces participants to adopt a reading strategy different from what they normally do. Fourth, the temporal resolution of the method depends on the size of the reading window. If the size is large, as it is, for example, in Experiments 3 and 4, the influences of different reading processes cannot be separately shown. In the case of small(er) units of presentation, reading can become rather tedious if larger texts have to be read.

The eye-movement registration technique does not have these shortcomings. It allows for the observation of normal reading behaviour. The method does not produce reading times that are affected by unrelated motor behaviour, does not elicit spill-over effects, allows readers to look back in the text, and has a high temporal resolution. In all of these aspects, the method is superior to the self-paced reading method. Of course, it has some disadvantages, too. The technique requires special equipment, sets constraints on the ability of participants, is more difficult to apply, and is more elaborate in its analysis.

The reading time measures resulting from the eye-movement registration technique are still subject to development. The present study contributes to this development by introducing a forward reading time measure that reflects ongoing reading processes and, furthermore, by showing that saccade durations have to be included in aggregated measures of reading time (Chapter 5).

The two techniques produced converging evidence on the reading processes investigated. One could conclude that since the self-paced reading method is more simple, it should be preferred over the more complex eye-movement registration technique. However, it should be noted that the specific deficits of the self-paced reading method make it more difficult to generalize to the normal reading situation. The eye-movement registration technique does not suffer from these drawbacks. It leads to an unobtrusive, fine-grained, and more in-depth view of the reading process as it occurs naturally. The conclusion, therefore, is that despite the greater effort required to obtain reading time data from eye-movement recordings, this method is to be preferred over the self-paced reading technique.

Knowledge availability and inference. Given that the two familiarity conditions reflected a high and a low level of availability (Chapter 2), the finding that the two levels of familiarity did not differentiate with respect to inferential processing is difficult to reconcile with the graded view on inferential processing proposed by Kintsch (1988) and McKoon and Ratcliff (1992). The graded view of inferential processing emerged from findings related to inferences about predictable events: The more evidence is obtained for such an inference, the stronger it becomes. In line with the minimalist approach to on-line inference making (McKoon & Ratcliff, 1992; McKoon & Ratcliff, 1995), which states that inferences are made on-line depending on their contribution to local coherence or on the availability of the reader's knowledge about them, one would have expected the familiarity of the causal relation to have shown a gradual influence on inference making. This, however, was not the case. The results of the present study are better explained from an all-or-nothing view on inference making. According to this view, which was held throughout the past twenty years of research on inferential processing, an inference is made or is not made at all.

The present study makes a case for an all-or-nothing view on inference making. However, the issue of whether inferences are made in a graded fashion or in an all-or-nothing fashion is by no means decided. Research should be directed at the question under what circumstances which inferences are made partially or completely.

The role of the connective. The present study on the processing of causal relations in the domain of general world knowledge shows that, even if the readers are knowledgeable about the content of a causal relation, the presence of the causal connective *because* is a prerequisite for the making of a causal inference. The inference is made to justify the causal relation. It requires an extra processing effort but results in a deeper understanding of the text. The fact that no evidence for inferencing was found if the connective was absent seems to be at odds with the findings of Keenan et al. (1984), Myers et al. (1987), and Duffy et al. (1990). They, too, investigated the processing of causal relations in the domain of general world knowledge and found evidence for inferential processing in the absence of a causal connective (see Chapter 1). However, in their studies, the texts consisted of only two sentences and one could claim that the experimental set up elicited the making of inferences. The sentences differed in causal strength to the point where the causal relations were really very implausible. Since the experimental task was to recall them after reading, there is not much the reader can do when reading two-sentence texts in these conditions but to find a relationship between the two sentences. In the experiments reported here, however, the causal relations were embedded in short texts and the causal relation sentences differed in no way in importance from the other sentences of the text. In this set up, the readers were not urged to make the causal inferences. The conclusion, therefore, is that there is no real contradiction between the studies, but that the different experimental settings elicited different reading behaviours.

The present results also differed from the findings of Simons (1993). Simons, too, found evidence for the inferential processing of causal relations in the absence of a causal connective. In one experiment, economic experts made a causal inference while reading a causal relation in the knowledge domain of economics. As pointed out in Chapter 3, the fact that the participants were economic experts reading texts on economic topics might have inclined them to call upon their expertise, enforcing the strategy of verifying the text rather than just reading it. Here, too, it seems that the experimental setting elicited the making of inferences.

It is reasonable to assume that, in comparison with these studies, the reading behaviour evoked in the present study resembles more strongly what readers do in a normal reading situation. An argument in favour of this assumption is that it is unlikely that readers normally engage in inferring a causal relation if no linguistic (or other, for example, task-related) cue is given. If no cue is given, the making of a causal inference requires a greater effort from the readers. They not only have to infer the information which justifies the causal relation, but they have to infer that the sentences are causally related as well. Concerning the latter inference, they are confronted with the problem of deciding what kind of relationship exists between the sentences: Is it causal, temporal, conclusive, contradictory, additive, etc.?

It is concluded, then, that in a normal reading situation, the making of a causal inference in the domain of general world knowledge depends on the knowledge of the reader about the causal relation *and* on the presence of a causal connective.

Integration and inference. The present study produces evidence for two different effects of the presence of the connective *because* on the processing of causal relations. It has a facilitating effect on the processing of the words immediately following the connective and a slowing-down effect on the processing of the final part of the sentence. The first effect was attributed to the process of sentence integration and the second effect to the inferential process (Chapters 3 and 4). The integration process entails the causal linking of the two clauses of the causal relation. The connective signals that the second clause is to be interpreted as the cause of the first. Since this information is given, the need to compute the relationship from the propositions in the sentence is removed and the words can be processed more easily. The inferential process consists of checking the causal relation against the reader's knowledge. The benefit of this process is a deeper understanding of the text, because it enables the reader to determine whether the relation makes any sense. Not making the inference would result in a more superficial understanding of the text, in which the causal relation is taken for granted. The making of an inference, however, comes with the cost of a prolonged reading time.

The two reading processes can be related to different levels of text representation. As mentioned before (see Section 3.4), it is generally accepted that there are three levels of text representation: a surface representation, a propositional representation, and a mental model representation (see, for example, Fletcher, 1994). The surface representation contains the literal wording of the text. The propositional representation contains the meaning of the sentences which can be expressed in terms of propositions. The mental model representation contains, in addition, information derived from the text on the basis of general knowledge. The three levels of representation are assumed to be constructed incrementally and in mutual dependence. As soon as surface information is available, propositions and relations between propositions are constructed, feeding the mental model with information to base derivations on. Although the three levels of representation are constructed more or less simultaneously, the processes which operate on them do have a temporal order. Propositions can only be constructed if surface information is available, and inferences can only be made if there are propositions to base them on. The processes of integration and inference can be understood as acting upon different levels of representation. The integration process can be seen as reflecting the construction of propositions. For instance, in the sentence *John was late because there was a traffic jam*, the propositions P1(late, John) and P2(is, traffic jam) are related causally by the proposition P3(cause, P2, P1). The connective *because* delivers proposition P3, simplifying the process of creating the propositional representation. The inferential process can be understood as adding to this representation the information from long-term memory that *traffic jams cause delay*, thereby justifying the causal relation. The idea that the processes of integration and inference relate to the propositional and the mental model representation, respectively, is supported by the finding that the integration effect is found earlier during sentence processing than the inference effect.

The present findings can well be accounted for in a framework of discourse comprehension based on the three levels of text representation. The framework is a working model for many researchers of reading comprehension processes and has, so far, predominantly been used to describe memory aspects of reading comprehension. The linking of specific reading comprehension processes to specific levels of text representation takes the model one step further and, hopefully, leads to a better understanding of the complex process of discourse comprehension.

References

Albrecht, J. E., & Myers, J. L. (1995). Role of context in accessing distant information during reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*(6), 1459–1468.

Altmann, G. T. M., Garnham, A., & Dennis, Y. (1992). Avoiding the garden path: Eye movements in context. *Journal of Memory and Language*, *31*, 685–712.

Black, J. B. (1985). An exposition on understanding expository text. In B. Britton & J. Black (Eds.), *Understanding expository text* (pp. 249–267). Hillsdale, NJ: Erlbaum.

Bransford, J. D., Barclay, J. R., & Franks, J. J. (1972). Sentence memory: A constructive versus interpretive approach. *Cognitive Psychology*, *3*, 193–209.

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, *20*, 37–46.

Cozijn, R. (1994). *Manual for the interactive analysis program of eye movement recordings: FIXATION*. Nijmegen, The Netherlands: Max Planck Institute for Psycholinguistics. [Internal paper].

Duffy, S. A., Shinjo, M., & Myers, J. L. (1990). The effect of encoding task on memory for sentence pairs varying in causal relatedness. *Journal of Memory and Language*, *29*, 27–42.

Ferreira, F., & Clifton, C. (1986). The independence of syntactic processing. *Journal of Memory and Language*, *25*, 348–368.

Findlay, J. M., & Walker, R. (1999). A model of saccade generation based on parallel processing and competitive inhibition. *Behavioral and Brain Sciences*, *22*, 661–721.

Fletcher, C. R. (1994). Levels of representation in memory for discourse. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 589–607). New York: Academic Press.

Fletcher, C. R., & Chrysler, S. T. (1991). Surface forms, textbases, and situation models: Recognition memory for three types of textual information. *Discourse Processes*, *13*, 175–190.

Frazier, L., & Rayner, K. (1982). Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology*, *14*, 178–210.

Garnham, A. (1989). Inference in language understanding: What, when, why, and how. In R. Dietrich & C. Graumann (Eds.), *Language processing in social context* (pp. 153–172). New York: Elseviers Science Publishers.

Glenberg, A. M., Meyer, M., & Lindem, K. (1987). Mental models contribute to foregrounding during text processing. *Journal of Memory and Language*, *26*, 69–83.

Graesser, A. C., Singer, M., & Trabasso, T. (1994). Constructing inferences during narrative text comprehension. *Psychological Review*, *101*, 371–395.

Haberlandt, K. F. (1982). Reader expectations in text comprehension. In J. F. Le Ny & W. Kintsch (Eds.), *Language and comprehension* (pp. 239–249). New York: North-Holland.

Haberlandt, K. F. (1984). Components of sentence and word reading times. In D. E. Kieras & M. A. Just (Eds.), *New methods in reading comprehension research* (pp. 219–251). Hillsdale, NJ: Erlbaum.

Halliday, M. A., & Hasan, R. (1976). *Cohesion in English*. London: Longman.

Inhoff, A. W., & Radach, R. (1998). Definition and computation of oculomotor measures in the study of cognitive processes. In G. Underwood (Ed.), *Eye guidance in reading and scene perception* (pp. 29–53). New York: Elsevier Science Publishers.

Irwin, D. E. (1998). Lexical processing during saccadic eye movements. *Cognitive Psychology*, *36*, 1–27.

Johnson-Laird, P. N. (1983). *Mental models: Towards a cognitive science of language, inference, and consciousness*. Cambridge: Cambridge University Press.

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review*, *87*, 329–354.

Katz, B., Müller, K., & Helmle, H. (1987). Binocular eye movement recording with CCD arrays. *Neuro-Ophthalmology*, *7*(2), 81–91.

Keenan, J. M., Baillet, S. D., & Brown, P. (1984). The effects of causal cohesion on comprehension and memory. *Journal of Verbal Learning and Verbal Behavior*, *23*, 115–126.

Kintsch, W. (1983). *The representation of meaning in memory*. Hillsdale, NJ: Erlbaum.

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction-integration model. *Psychological Review*, *95*, 163–182.

Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. Cambridge: Cambridge University Press.

Kintsch, W., Welsch, D., Schmalhofer, F., & Zimny, S. (1990). Sentence memory: A theoretical analysis. *Journal of Memory and Language*, *29*, 133–159.

Konieczny, L. (1996). *Human sentence processing: A semantics-oriented parsing approach*. Ph.D. thesis, IIG-Reports 3/96, Universität Freiburg, Institut für Informatik und Gesellschaft.

Konieczny, L., Hemforth, B., Scheepers, C., & Strube, G. (1995). PP-attachment in German: Results from eye movement studies. In J. M. Findlay, R. Walker, & R. W. Kentridge (Eds.), *Eye movement research: Mechanisms, processes, and applications* (pp. 405–420). New York: North-Holland.

Liversedge, S. P., Paterson, K. B., & Pickering, M. J. (1998). Eye movements and measures of reading time. In G. Underwood (Ed.), *Eye guidance in reading and scene perception* (pp. 55–75). New York: Elsevier Science Publishers.

McKoon, G., Gerrig, R. J., & Greene, S. B. (1996). Pronoun resolution without pronouns: Some consequences of memory-based text processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*(4), 919–932.

McKoon, G., & Ratcliff, R. (1980). The comprehension processes and memory structures involved in anaphoric reference. *Journal of Verbal Learning and Verbal Behavior, 19*, 668–682.

McKoon, G., & Ratcliff, R. (1992). Inference during reading. *Psychological Review*, *99*, 440–466.

McKoon, G., & Ratcliff, R. (1995). The minimalist hypothesis: Directions for research. In I. C. A. Weaver, S. Mannes, & C. R. Fletcher (Eds.), *Discourse comprehension: Essays in honor of Walter Kintsch* (pp. 97–116). Hillsdale, NJ: Erlbaum.

Millis, K. K., Golding, J. M., & Barker, G. (1995). Causal connectives increase inference generation. *Discourse Processes, 20*, 29–49.

Millis, K. K., & Just, M. A. (1994). The influence of connectives on sentence comprehension. *Journal of Memory and Language*, *33*, 128–147.

Morrow, D. G., Bower, G. H., & Greenspan, S. L. (1989). Updating situation models during narrative comprehension. *Journal of Memory and Language*, *28*, 292–312.

Myers, J. L., & O'Brien, E. J. (1998). Accessing the discourse representation during reading. *Discourse Processes*, *26*(2/3), 131–157.

Myers, J. L., Shinjo, M., & Duffy, S. A. (1987). Degree of causal relatedness and memory. *Journal of Memory and Language*, *26*, 453–465.

Noordman, L. G. M., & Vonk, W. (1992). Reader's knowledge and the control of inferences in reading. *Language and Cognitive Processes*, *7*(3/4), 373–391.

Noordman, L. G. M., & Vonk, W. (1997). The different functions of a conjunction in constructing a representation of the discourse. In J. Costermans & M. Fayol (Eds.), *Processing interclausal relationships: Studies in the production and comprehension of text* (pp. 75–93). Mahwah, NJ: Erlbaum.

Noordman, L. G. M., & Vonk, W. (1998). Memory-based processing in understanding causal information. *Discourse Processes*, *26*(2/3), 191–212.

Noordman, L. G. M., Vonk, W., & Kempff, H. J. (1992). Causal inferences during the reading of expository texts. *Journal of Memory and Language*, *13*, 573–590.

Perrig, W., & Kintsch, W. (1985). Propositional and situational representation of text. *Journal of Memory and Language*, *24*, 503–518.

Pollatsek, A., & Well, A. D. (1995). On the use of counterbalanced designs in cognitive research: A suggestion for a better and more powerful analysis. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*(3), 785–794.

Rayner, K. (1995). Eye movements and cognitive processes in reading, visual search, and scene perception. In J. M. Findlay, R. Walker, & R. W. Kentridge (Eds.), *Eye movement research: Mechanisms, processes, and applications* (pp. 1–22). New York: Elsevier Science Publishers.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, *124*(3), 372–422.

Rayner, K., & Duffy, S. A. (1986). Lexical complexity and fixation times in reading: Effects of word frequency, verb complexity, and lexical ambiguity. *Memory & Cognition*, *14*, 191–201.

Rayner, K., & Pollatsek, A. (1989). *The psychology of reading*. Englewood Cliffs, NJ: Prentice Hall.

Rayner, K., & Sereno, S. C. (1994a). Eye movements in reading: Psycholinguistic studies. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 57–82). New York: Academic Press.

Rayner, K., & Sereno, S. C. (1994b). Regression-contingent analyses: A reply to Altmann. *Memory & Cognition*, *22*(3), 291–292.

Rayner, K., & Sereno, S. C. (1994c). Regressive eye movements and sentence parsing: On the use of regression-contingent analyses. *Memory & Cognition*, *22*(3), 281–285.

Rayner, K., Sereno, S. C., Morris, R. K., Schmauder, A. R., & Clifton, C. (1989). Eye movements and on-line language comprehension processes [special issue]. *Language and Cognitive Processes*, *4*(3/4), 21–49.

Sanders, T. J. M., & Noordman, L. G. M. (2000). The role of coherence relations and their linguistic markers in text processing. *Discourse Processes*, *29*(1), 37–60.

Sanford, A. J. (1990). On the nature of text-driven inference. In D. A. Balota, G. B. Flores d'Arcais, & K. Rayner (Eds.), *Comprehension processes in reading* (pp. 515–535). Hillsdale, NJ: Erlbaum.

Schank, R. C., & Abelson, R. (1977). *Scripts, plans, and goals*. Hillsdale, NJ: Erlbaum.

Schmalhofer, F., & Glavanov, D. (1986). Three components of understanding a programmer's manual: Verbatim, propositional, and situational representations. *Journal of Memory and Language*, *25*, 279–294.

Simons, W. H. G. (1993). *De regulering van inferenties door de kennis van de lezer*. Ph.D. thesis, Nijmegen University, Nijmegen, The Netherlands. [The control of inferences by the knowledge of the reader].

Singer, M. (1988). Inferences in reading comprehension. In M. Daneman, G. E. MacKinnon, & T. G. Waller (Eds.), *Reading research: Advances in theory and practice* (vol. 6, pp. 177–219). New York: Academic Press.

Singer, M. (1994). Discourse inference processes. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 479–515). New York: Academic Press.

Singer, M., Halldorson, M., Lear, J. C., & Andrusiak, P. (1992). Validation of causal bridging inferences in discourse understanding. *Journal of Memory and Language*, *31*, 507–524.

Trabasso, T., Van den Broek, P. W., & Suh, S. Y. (1989). Logical necessity and transitivity of causal relations in stories. *Discourse Processes*, *12*, 1–25.

Trueswell, J. C., Tanenhaus, M. K., & Garnsey, S. M. (1994). Semantic influences on parsing: Use of the thematic role information in syntactic ambiguity resolution. *Journal of Memory and Language*, *33*, 285–318.

Van den Broek, P. (1994). Comprehension and memory of narrative texts. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 539–588). New York: Academic Press.

Van Dijk, T. A., & Kintsch, W. (1983). *Strategies of discourse comprehension*. New York: Academic Press.

Vonk, W., & Noordman, L. G. M. (1990). On the control of inferences in text understanding. In D. A. Balota, G. B. Flores d'Arcais, & K. Rayner (Eds.), *Comprehension processes in reading* (pp. 447–464). Hillsdale, NJ: Erlbaum.

Vonk, W., Radach, R., & van Rijn, H. (2000). Eye guidance and the saliency of word beginnings in reading text. In A. Kennedy, R. Radach, D. Heller, & J. Pynte (Eds.), *Reading as a perceptual process* (pp. 269–299). Amsterdam: Elsevier Science Publishers.

Appendices

A Length correction of reading times

In Experiments 3 and 4 (Chapter 3), clause-reading times were compared in two conditions: with the connective *because* and without it. For instance, the reading of the clause *because there was a traffic jam on the highway* was compared to the reading of the clause *There was a traffic jam on the highway*. The interest in the experiments lies in the role of the connective *because* on the reading of the clause. It was hypothesised that the connective would elicit the making of an inference, which is time-consuming and results in longer reading times if the connective is present compared to when it is absent. A problem with this comparison is that the clauses in the two conditions differ in length and that length is an important component of reading times (see, for example, Haberlandt, 1984). The longer the clause, the longer the reading time of that clause will be. A direct comparison of the reading times in the two conditions is, therefore, not possible. Any effect attributable to the presence of the connective would be contaminated by the mere fact that the clauses containing the connective are longer.

At first glance, a way to solve the problem is to divide the reading times by the number of characters or syllables or words. However, although some still propagate it (Kintsch, 1998), it has been extensively shown that this method is extremely flawed (Ferreira & Clifton, 1986; Konieczny, 1996; Trueswell et al., 1994). A major problem with length division is that length as a linear component has an intercept, that is, the reading times of, for example, short words does not approach zero but has a lower bound well above zero. As a result of this intercept, division by length tends towards greater distortion at smaller lengths.

For this reason, it was proposed that a length correction on the basis of a linear regression analysis should be performed, in which length is entered as a predictor of reading times (Ferreira & Clifton, 1986). The residuals resulting from this procedure, that is, the original reading times minus the predicted times, could then be entered as dependent variable in the main analysis. To avoid the problem of individual differences, it was suggested that the method be applied for each participant separately.

An important issue in linear regression analysis is the determination of the data set on which the linear regression is to be based. The set should be reasonably large to ensure the reliability of the predictor, but it should not contain any materials that have been experimentally manipulated. For instance, in the calculation of the linear regression residuals of the reading times in Experiment 3, the target clauses, that is, the clauses that do or do not contain the connective *because* should not be part of the data set. The reason is, simply, that this would result in the contamination of the linear regression residuals with the experimental manipulation of the materials. Other sources of distortion are first and last sentences of texts, because first sentences often take more time to read than when presented at an intermediate location in the text, and last sentences are often read faster.

The procedure of length correction can be illustrated by the clause-reading time data of Experiment 3. Analyses of variance were performed on the unadjusted clause-reading times, the clause-reading times divided by clause length in characters, the linear regression residuals with clause length as predictor and the target-clause reading times as predictor set, and the linear regression residuals with clause length as predictor and the reading times of all the clauses except the target clause, and the first and last clauses, i.e., 2, 3, 4, 5, and 7 of the experimental texts, as predictor set.

All analyses were performed with participants as random factor (F_1) and items as random factor (F_2) as in Chapter 3, with the within participants and within items factors presence of the connective (Connective) and familiarity of the causal relation (Familiarity) and the between participants and between items factor group. Reading times belonging to items on which a verification error had been made were excluded from the analyses as well as outliers exceeding 2.0 *SD* from the participants and items means within condition. By way of illustration, only the results of the factor Connective will be reported.

The unadjusted clause-reading times (see Table A.1) showed a significant effect of the factor Connective in the participants analysis: $F_1(1,28) = 6.29$, $MSE = 49912$, $p < 0.05$; $F_2(1,20) = 1.10$, $MSE = 70821$, $p > 0.3$. If the connective was present, the reading times were longer. Note that the effect of the connective here is contaminated with clause length. The clauses containing the connective were longer and the effect found could just as well reflect that.

Table A. 1: Unadjusted mean reading times (ms) as a function of Familiarity and Connective (Experiment 3).

	Connective	
Familiarity	present	absent
very familiar	2011	1909
not very familiar	2048	1952

The mean reading times divided by clause length (Table A.2) showed a significant effect of the factor Connective, too. However, it was in the opposite direction. Reading times were shorter if the connective was present than if it was absent: $F_1(1,28) = 29.65$, $MSE = 22$, $p < 0.001$; $F_2(1,20) = 14.20$, $MSE = 53$, $p < 0.01$. The division by clause length results in a strong effect of Connective in the opposite direction of the previous analysis.

In the analyses of the linear regression residuals with clause length as predictor and the target-clause reading times as predictor set (see Table A.3), there was no effect of the factor Connective: $F_1(1,28) < 1$; $F_2(1,20) < 1$.

Table A. 2: Mean reading times divided by clause length (ms) as a function of Familiarity and Connective (Experiment 3).

	Connective	
Familiarity	present	absent
very familiar	44.45	49.14
not very familiar	45.98	50.39

Table A. 3: Mean linear regression reading time residuals (ms) after correction for clause length based on the target clause reading times as a function of Familiarity and Connective (Experiment 3).

	Connective	
Familiarity	present	absent
very familiar	-31.58	-21.07
not very familiar	6.39	35.46

Finally, the linear regression residuals with clause length as predictor and the reading times of clauses 2, 3, 4, 5, and 7 of the experimental texts as predictor set (Table A.4) showed no effect of the factor Connective either: $F_1(1,28) = 2.14$, $MSE = 41882$, $p = 0.15$; $F_2(1,20) = 2.34$, $MSE = 49938$, $p = 0.14$.

As is clear from this illustration, all three types of analyses, i.e., the raw reading times analyses, the length-division analyses, and the linear regression residuals analyses, generate different and even contradictory outcomes. This stresses the importance of choosing the right type of analysis for interpretation.

The two different linear regression residuals analyses produce similar results. There is no effect of the connective. However, it should be noted

Table A. 4: Mean linear regression reading time residuals (ms) after correction for clause length based on the reading times of clauses 2, 3, 4, 5, and 7 of the experimental texts as a function of Familiarity and Connective (Experiment 3).

	Connective	
Familiarity	present	absent
very familiar	-176.34	-131.81
not very familiar	-135.44	-74.08

that the means residuals analysis with a length correction based on the target clauses is flawed. In this analysis, the estimation of the influence of length on the reading times is contaminated with any effect of the experimental manipulation of the data on which the correction is based (see also Konieczny, 1996). In the present example, the analyses only hint at such a distortion. The mean residuals based on the target clause length correction show smaller differences as a function of the presence of the connective than the mean residuals resulting from length correction based on clauses 2, 3, 4, 5, and 7 of the experimental texts. Although no solid conclusions can be drawn on the basis of these analyses, the means of the latter analysis do point at the possibility that the connective tended to produce faster reading times.

Conclusion

Length correction of reading times should not be based on division by number of characters but on (by-participant) linear regression analyses which have as a data set the reading times of parts of the materials other than those that are affected by the experimental manipulation.

B Materials of Experiments 3 and 4 (Chapter 3)

The texts are presented in the connective *because* (omdat) absent condition. In the connective present condition, the sentence preceding the connective ends with a comma and the first word after the connective is not capitalised. In Dutch, the word order of the *because*-clause changes to SOV.
Legend:
vf = very familiar causal relation
nvf = not very familiar causal relation
(omdat) = condition with *because*.
Probe recognition words are <u>underlined</u>

1
De heer Smit verliet rond half acht het huis.
Hij moest op zijn werk een belangrijke vergadering voorzitten.
Daarom was hij van plan om die morgen de papieren goed door te nemen.
Hij haalde zijn auto uit de garage en reed weg.
Op weg naar het werk had hij die <u>ochtend</u> vertraging.
vf (omdat) Er was op de snelweg een lange file ontstaan.
nvf (omdat) Er was op de snelweg politiebewaking.
Hij was blij dat hij wat eerder was vertrokken.
Hij hield er niet van om te laat te komen.
verification:
vf Een file op de snelweg leidt tot vertraging.
nvf Politiebewaking op de snelweg leidt tot vertraging.

2
Karel en Marijke wilden een huis in Alkmaar kopen.
Ze brachten een bezoek aan een makelaar.
Die ging met hen naar een woning kijken.
Het was een groot huis aan een rustige straat.
Ze besloten om het huis in de <u>stad</u> echter niet te kopen.
vf (omdat) Het was voor hun doen eigenlijk erg duur.
nvf (omdat) Er moest een onderhuurder in worden geduld.
De makelaar toonde hun daarna nog enkele andere huizen.
Hij hoopte dat daar wel een geschikte tussen zat.
verification:
vf Als een huis voor jou erg duur is, zie je van de koop af.
nvf Als in een huis een onderhuurder moet worden geduld, zie je van de koop af.

3
Meneer de Bruin kwam gehaast uit kantoor en stapte in zijn auto.
Hij had beloofd om vroeg thuis te zijn.
Hij reed zijn wagen het parkeerterrein af.
Al vlug bevond hij zich op de snelweg.
Na een <u>paar</u> kilometer werd hij aangehouden door de politie.
vf (omdat) Hij had dat stuk heel erg hard gereden.
nvf (omdat) Hij had een kapotte achterverlichting.
Zoals aangegeven zette hij zijn wagen aan de kant.
Hij kreeg een behoorlijke boete.
verification:
vf Voor hard rijden word je door de politie aangehouden.
nvf Voor rijden zonder licht word je door de politie aangehouden.

4
Kees was gewend om vaak uit te gaan.
Meestal bezocht hij dezelfde kroeg.
Rond twaalf uur kwam hij uit het café naar buiten.
Hij hield een voorbijkomende taxi aan.
Kees was die <u>avond</u> niet in staat om naar huis te rijden.
vf (omdat) Hij had dit keer heel erg veel gedronken.

nvf (omdat) Hij was door iemand in elkaar geslagen.
Hij stapte in de taxi die vervolgens langzaam de straat uitreed.
Zijn auto zou hij later wel een keer ophalen.
verification:
vf Als je erg veel hebt gedronken, kun je niet autorijden.
nvf Als je in elkaar bent geslagen, kun je niet autorijden.

5
Pieter de Vries wilde zijn verjaardag vieren met een groot feest.
Hij was de hele dag in de weer met inkopen doen.
Daarna ruimde hij zijn huiskamer leeg om iedereen te kunnen ontvangen.
Tegen elven waren alle gasten aanwezig en was het feest in volle gang.
Na een <u>uur</u> kwamen zijn buren geprikkeld hun beklag doen.
vf (omdat) Hij maakte met zijn feest erg veel lawaai.
nvf (omdat) Hij blokkeerde met zijn auto hun oprit.
Pieter bood zijn excuses aan.
Hij beloofde dat er snel verandering in zou komen.
verification:
vf Veel lawaai op een feest leidt tot klachten.
nvf Blokkeren van iemands oprit leidt tot klachten.

6
De heer Peper besteedde erg veel zorg aan zijn wagen.
Elke zaterdag waste en poetste hij hem.
Als trouwe klant kwam hij regelmatig bij de garage.
Al meer dan vijftien jaar ging hij naar hetzelfde bedrijf.
Afgelopen <u>week</u> bracht hij zijn auto naar de garage.
vf (omdat) Hij moest hem laten repareren.
nvf (omdat) Hij wilde hem over laten spuiten.
Hij was altijd erg zuinig geweest op zijn auto.
Hij hoopte dat het niet te duur zou uitvallen.
verification:
vf Voor het laten repareren van een auto moet je naar de garage.
nvf Voor het over laten spuiten van de auto moet je naar de garage.

7
Aan de Wezenlaan in Aalten was het goed wonen.
Het was een levendige straat in een mooie wijk.
Veel gezinnen woonden er al meer dan twintig jaar.
Sinds kort was het straatbeeld enigszins veranderd.
Automobilisten konden er vanaf vorige <u>maand</u> niet meer zo hard rijden.
vf (omdat) Er waren door de gemeente verkeersdrempels geplaatst.
nvf (omdat) Er waren rioleringswerkzaamheden aan de weg.
De bewoners waren zeer te spreken over de nieuwe situatie.
Het verkeer was er nu een stuk rustiger.
verification:
vf Verkeersdrempels dwingen automobilisten langzamer te rijden.
nvf Rioleringswerkzaamheden aan de weg dwingen automobilisten langzamer te rijden.

8
Carina had via de Wehkamp een muziekinstallatie besteld.
Na zes dagen werd de installatie afgeleverd.
Hij was klein en niet duur, precies wat ze wilde.
Ze besloot om hem te nemen en stuurde de meegeleverde acceptgiro op.
De bank voerde de <u>opdracht</u> tot betaling echter niet uit.
vf (omdat) Ze had vergeten haar handtekening te zetten.
nvf (omdat) Er was een staking bij het personeel van de bank.
Ze zou het bedrag pas later over kunnen maken.
Ze hoopte dat de vertraging geen problemen op zou leveren.
verification:
vf Ongetekende betalingsopdrachten worden door de bank niet uitgevoerd.
nvf Stakend bankpersoneel voert betalingsopdrachten niet uit.

9
De heer en mevrouw Steegs gingen dit jaar naar Zuid-Frankrijk op vakantie.

Ze hadden besloten om met de wagen te gaan.
Het was een lange tocht en mevrouw Steegs verveelde zich.
Ze wilde graag iets doen maar wist niet wat.
Ze kon tijdens de <u>rit</u> in de auto haar boek niet lezen.
vf (omdat) Ze had gauw last van wagenziekte.
nvf (omdat) Ze had haar leesbril niet bij zich.
Halverwege de dag zou zij het stuur overnemen.
Dan moest ze daar maar op wachten.
verification:
vf Wie gauw last heeft van wagenziekte, kan in een auto geen boek lezen.
nvf Wie een leesbril nodig heeft, kan zonder bril geen boek lezen.

10
Na een lange reis kwam de familie Peters aan in het Franse plaatsje Beaune.
Buiten het plaatsje vonden ze een hotel gelegen aan het water.
Meneer Peters ging naar binnen en meldde zich bij de receptie.
Teleurgesteld kwam hij even later weer buiten.
Ze konden in het hotel aan het <u>meer</u> niet overnachten.
vf (omdat) Het was al helemaal volgeboekt.
nvf (omdat) Er werd een wijncongres gehouden.
Verderop zou nog een hotel moeten liggen.
Misschien hadden ze daar meer geluk.
verification:
vf Als een hotel volgeboekt is, kun je er geen kamer meer krijgen.
nvf Als in een hotel een congres wordt gehouden, kun je er geen kamer meer krijgen.

11
Met lood in zijn schoenen was Harm naar school gegaan.
Er stond vandaag een proefwerk wiskunde op het programma.
Het vak werd in het vierde uur gegeven.
De docent had het hele uur ervoor uitgetrokken.
Harm kon met de beste <u>wil</u> geen enkele vraag goed beantwoorden.
vf (omdat) Hij had de stof erg slecht bestudeerd.
nvf (omdat) Hij had last van een zware hoofdpijn.
Hij hoopte dat hij het later nog kon compenseren.
Wiskunde was niet zijn slechtste vak.
verification:
vf Wie slecht voor een proefwerk leert, kan de vragen niet goed beantwoorden.
nvf Wie last heeft van hoofdpijn, kan op proefwerkvragen niet goed antwoord geven.

12
De Ronde van Vlaanderen was dit keer sterk bezet.
Wielrenners van internationale allure namen eraan deel.
De lange tocht werd in de massasprint gewonnen door een Italiaan.
Het was zijn eerste zege in een zo zwaar bezet veld.
Na de wedstrijd werd de winnaar van de <u>race</u> echter gediskwalificeerd.
vf (omdat) Hij werd betrapt op dopinggebruik.
nvf (omdat) Hij had een official omgekocht.
De kranten maakten uitgebreid melding van het voorval.
De Italiaan zou lang niet meer in wedstrijden mogen uitkomen.
verification:
vf Als je op dopinggebruik betrapt wordt, word je gediskwalificeerd.
nvf Als je bij een wedstrijd een official omkoopt, word je gediskwalificeerd.

13
Cisca was in de zomer met een georganiseerde reis naar Kenia gegaan.
Ze ging eerst op safari door een natuurpark.
Daarna maakte ze een rondrit langs alle bezienswaardigheden.
In een bus trok de groep door het tropische land.
Cisca had elke <u>nacht</u> veel moeite om de slaap te vatten.
vf (omdat) Ze was niet gewend aan het bijzonder warme weer.
nvf (omdat) Ze was niet gewend in vreemde bedden te slapen.
De vakantie verliep verder zonder problemen.
Het was een ervaring die ze niet graag gemist zou hebben.
verification:

vf Als je bij een wedstrijd een official omkoopt, word je gediskwalificeerd.
nvf Wie niet gewend is in vreemde bedden te slapen, heeft moeite met inslapen.

14
Jaap was deze morgen bij de tandarts geweest.
Op twee plaatsen in zijn mond was hij aan zijn kiezen geboord.
Hij moest naar huis om zijn spullen te halen en daarna naar school.
Zijn moeder had net koffie gezet en stelde voor een plakje cake te nemen.
Jaap sloeg het aanbod van koffie met cake echter af.
vf (omdat) Hij mocht van de tandarts nog niet eten.
nvf (omdat) Hij had verschrikkelijk veel haast.
Hij pakte snel zijn spullen en stapte weer op de fiets.
Gelukkig hoefde hij niet ver te rijden.
verification:
vf Wie van de tandarts nog niet mag eten, slaat koffie met cake af.
nvf Wie veel haast heeft, slaat koffie met cake af.

15
Mevrouw Wenders had een nieuwe rok nodig.
Het was erg lang geleden dat ze kleren had gekocht.
Na lang zoeken vond ze een aardig boetiekje.
Daar hing een mooie zijden rok die haar ook goed paste.
Na enige aarzeling nam ze de rok toch niet.
vf (omdat) Ze vond hem behoorlijk duur.
nvf (omdat) Ze vond dat de kleur haar slecht stond.
Gelukkig waren er nog genoeg plaatsen om te kijken.
Ze was vastbesloten om die dag te slagen.
verification:
vf Als je een rok erg duur vindt, neem je hem niet.
nvf Als je vindt dat de kleur je lelijk staat, neem je een rok niet.

16
Het was herfst en Pierre was hard aan vakantie toe.
Hij had besloten om drie weken naar Portugal te gaan.
Nadat alles was geregeld kon hij eindelijk weg.
Op Schiphol aangekomen meldde hij zich meteen aan.
Alle vluchten waren echter voor onbepaalde tijd uitgesteld.
vf (omdat) Boven het vliegveld hing een dichte mist.
nvf (omdat) Op het vliegveld was een toestel neergestort.
Hij besloot om ergens koffie te gaan drinken.
Het zou wel even duren voor hij echt kon vertrekken.
verification:
vf Dichte mist op het vliegveld veroorzaakt vertragingen.
nvf Het neerstorten van een toestel op het vliegveld veroorzaakt vertragingen.

17
De rijke man had zijn buren voor een kennismaking uitgenodigd.
Hij woonde nog maar kort in de nieuwe buurt.
Na de koffie liet hij zijn grote woning zien.
Hij gaf een rondleiding door het hele huis.
Alleen de kamers op de bovenste etage sloeg hij over.
vf (omdat) Hij had daar nog tamelijk veel rommel liggen.
nvf (omdat) Hij had die kamers aan iemand onderverhuurd.
De buren waren erg onder de indruk.
Zij nodigden hem uit voor een tegenbezoek.
verification:
vf Rommelige kamers sla je bij een rondleiding over.
nvf Onderverhuurde kamers sla je bij een rondleiding over.

18
Angelique wilde samen met haar vriendin naar een popconcert gaan.
Het was een concert van haar meest geliefde band.
Haar moeder had haar na lang zeuren het geld voorgeschoten.
Ze ging naar een kantoor waar kaartjes verkocht werden.
Angelique kon op het bureau echter geen kaartje kopen.

vf (omdat) Alle kaartjes waren uitverkocht.
nvf (omdat) Ze was voor het popconcert te jong.
De teleurstelling was op haar gezicht te lezen.
Nu ze dan eindelijk van thuis mocht, kon ze niet mee.
verification:
vf Als alle kaartjes op zijn, kun je er geen meer kopen.
nvf Als je te jong bent voor een popconcert, kun je er geen kaartje voor kopen.

19
Annelies had net haar eindexamen met succes afgelegd.
Haar ouders waren bijzonder trots op haar.
In augustus zou ze gaan studeren.
Ze had nu een zee van tijd.
Ze besloot om in elk geval een periode te werken.
vf (omdat) Ze wilde maar al te graag wat geld verdienen.
nvf (omdat) Ze wilde ervaring opdoen in een bedrijf.
Samen met haar vriendin zou ze dan op vakantie kunnen.
Voor de studie hoefde ze pas in augustus terug te zijn.
verification:
vf Als je geld wilt verdienen, moet je werken.
nvf Als je ervaring in het bedrijfsleven op wilt doen, moet je werken.

20
Erik en Petra besloten eens uit te gaan eten.
Hun keuze was gevallen op een Japans restaurant.
Vlak na zevenen liepen ze de zaak binnen.
In de volle zaak ontdekten ze achterin een vrije tafel.
Ze konden aan die tafel in de hoek echter niet plaatsnemen.
vf (omdat) Hij was reeds voor anderen gereserveerd.
nvf (omdat) Hij was uitsluitend bedoeld voor het personeel.
Voor het wachten kregen ze aan de bar een drankje van de zaak.
Een dergelijke service hadden ze nog niet eerder meegemaakt.
verification:
vf Aan een voor anderen gereserveerde tafel kun je niet plaatsnemen.
nvf Aan een tafel bedoeld voor het personeel kun je niet plaatsnemen.

21
Elvira had problemen met haar cassetterecorder.
Hij speelde wel goed af, maar nam niet meer op.
Ze besloot om hem naar een grote electronicazaak te brengen.
Daar werd een mankement aan één van de onderdelen geconstateerd.
De firma in het centrum kon het toestel echter niet meteen maken.
vf (omdat) Ze hadden het onderdeel niet in voorraad.
nvf (omdat) Ze hadden het druk met andere klanten.
Elvira zou waarschijnlijk twee weken moeten wachten.
Het bedrijf zou bellen als het toestel gemaakt was.
verification:
vf Als een onderdeel niet in voorraad is, kan een toestel niet meteen gemaakt worden.
nvf Als een firma het druk heeft, kunnen reparaties niet meteen worden uitgevoerd.

22
Jonas moest voor Duits een spreekbeurt houden.
Hij wilde over de uitvinding van de fiets gaan spreken.
In de Openbare Bibliotheek vond hij in de catalogus een geschikt boek.
Toen hij in de schappen zocht, kon hij het boek echter niet vinden.
Aan de balie vernam hij dat het boek niet aanwezig was.
vf (omdat) Het was op dat moment aan iemand uitgeleend.
nvf (omdat) Het was op dat moment bij de boekbinder.
Hij besloot naar een andere bibliotheek te gaan.
Misschien had hij daar meer succes.
verification:
vf Als een boek uitgeleend is, kun je het niet lenen.
nvf Als een boek bij de boekbinder is, kun je het niet lenen.

23

Anouk was naar de film geweest met haar vriendin Chantal.
Ze hadden van de film genoten en dronken daarna nog wat in een café.
Rond half één gingen ze naar huis.
Chantal woonde dichtbij, maar Anouk moest nog een stuk lopen.
Anouk vermeed tijdens haar <u>wandeling</u> naar huis het donkere park.
vf (omdat) Ze was bang lastig gevallen te worden.
nvf (omdat) Ze had nogal veel last van nachtblindheid.
Toen ze na twintig minuten thuis kwam ging ze meteen naar bed.
Ze moest de volgende dag weer vroeg op.
verification:
vf Als je bang bent lastig gevallen te worden, vermijd je donkere parken.
nvf Als je last hebt van nachtblindheid, vermijd je donkere parken.

24
Arjen was met de auto op weg naar een vriend in Amsterdam.
Eenmaal in de stad aangekomen raakte hij spoedig de weg kwijt.
Hij besloot een voetganger om hulp te vragen.
Hij zette zijn auto aan de kant en hield een meisje staande.
Ze kon hem tot haar <u>spijt</u> echter de weg niet wijzen.
vf (omdat) Ze kwam van buiten de grote stad.
nvf (omdat) Ze sprak zeer gebrekkig Nederlands.
Bij de volgende voetganger had Arjen meer succes.
Hij bleek nog een behoorlijk eind te moeten rijden.
verification:
vf Als je van buiten de stad komt, kun je iemand de weg niet wijzen.
nvf Als je de taal slecht spreekt, kun je iemand de weg niet wijzen.

C Materials of Experiments 5 and 6 (Chapter 4)

The texts are presented in the connective *because* (omdat) absent condition. In the connective present condition, the sentence preceding the connective ends with a comma and the first word after the connective is not capitalised. In Dutch, the word order of the *because*-clause changes to SOV.
Legend:
vf = very familiar causal relation
nvf = not very familiar causal relation
(omdat) = condition with *because*.
/ = unit separator

1
De heer Smit/ verliet rond half acht/ het huis./ Hij moest op
zijn werk/ een belangrijke vergadering/ voorzitten./ Daarom was hij
van plan/ om van tevoren/ de papieren/ goed door te nemen./ Hij haalde
zijn auto/ uit de garage/ en reed weg./ Hij ondervond/ een flinke
vf vertraging./ (omdat)/ Er/ was een lange file ontstaan/ op de snelweg./ Hij
nvf vertraging./ (omdat)/ Er/ was een snelheidscontrole/ op de snelweg./ Hij
was blij/ dat hij wat eerder/ was vertrokken./ Hij hield er niet van
om te laat/ te komen.
verification:
vf Een file op de snelweg leidt tot vertraging.
nvf Een snelheidscontrole op de snelweg leidt tot vertraging.

2
Karel en Marijke/ waren op zoek/ naar een huis/ in Amsterdam.
Ze brachten/ een bezoek/ aan het kantoor/ van een makelaar./ De
makelaar/ ging met hen/ naar een woning kijken./ Het was een groot
huis/ aan een rustige straat./ Ze besloten/ om/ het huis/ niet te
vf kopen./ (omdat)/ Er/ werd te veel geld gevraagd/ voor het pand./ De
nvf kopen./ (omdat)/ Er/ was een gedeelte verhuurd/ aan een onderhuurder./ De
makelaar/ toonde hen/ daarna nog/ enkele andere huizen./ Hij hoopte
dat daar/ wel een geschikte/ tussen zat.
verification:
vf Als een pand te duur is, koop je het niet.
nvf Als een huis onderverhuurd is, koop je het niet.

3
Meneer Vos/ verliet zijn kantoor/ en stapte/ in zijn auto./ Het was al
zeven uur/ en hij had/ zijn vrouw beloofd/ om vroeg thuis/ te zijn./ Hij
woonde helemaal/ aan de andere kant/ van de stad./ Hij reed/ zijn wagen
het parkeerterrein af./ Na een tijdje/ werd hij aangehouden/ door de
vf politie./ (omdat)/ Hij/ had veel te hard gereden/ in de bebouwde kom./ Zoals
nvf politie./ (omdat)/ Hij/ reed met een kapot achterlicht/ in het donker./ Zoals
aangegeven/ zette hij zijn wagen/ aan de kant./ Hij kreeg van de politie
een bekeuring.
verification:
vf Voor te hard rijden word je door de politie aangehouden.
nvf Voor rijden met een kapot licht word je door de politie aangehouden.

4
Kees was gewend/ om/ vaak uit te gaan./ Meestal bezocht hij/ dezelfde
kroeg./ Ook dit keer/ was hij/ naar zijn stamcafé/ in de stad gegaan.
Het was vrijdagavond/ en in het café/ was het drukker/ en rumoeriger
dan anders./ Hij was na afloop/ niet in staat/ om/ naar huis te
vf rijden./ (omdat)/ Hij/ had te veel gedronken/ op die avond./ De barkeeper
nvf rijden./ (omdat)/ Hij/ was gewond geraakt/ in een ruzie./ De barkeeper
bestelde een taxi/ voor hem./ Zijn auto/ zou hij/ later een keer/ op
moeten halen.
verification:

vf Met te veel drank op kun je niet autorijden.
nvf Met ernstige verwondingen kun je niet autorijden.

5
De heer Polman/ besteedde/ erg veel zorg/ aan zijn wagen./ Elke zaterdagochtend/ waste en poetste/ hij hem./ Hij had hem/ enige tijd geleden/ tweedehands gekocht/ bij zijn garage./ Als trouwe klant/ had hij een gunstige prijs/ weten te bedingen./ Deze week/ bracht hij hem/ naar de
vf garage./ (omdat)/ De auto/ had startproblemen/ in het koude weer./ Het
nvf garage./ (omdat)/ De auto/ zou worden overgespoten/ in een andere kleur./ Het bedrijf/ gaf hem zolang/ een leenauto./ Die kon hij gebruiken/ tot zijn auto/ weer klaar was.
verification:
vf Als je auto startproblemen heeft, breng je hem naar de garage.
nvf Als je je auto wilt laten overspuiten, breng je hem naar de garage.

6
De Wezenlaan/ in Aalten/ was een gunstig gelegen straat/ om aan te wonen. Het enige bezwaar/ was de toenemende drukte/ op de weg./ Er woonden veel gezinnen/ met kleine kinderen./ Na aanhoudende klachten/ had de gemeente/ daar onlangs/ wat aan gedaan./ Auto's/ konden er/ niet meer/ hard
vf rijden./ (omdat)/ Er/ waren drempels geplaatst/ voor het verkeer./ De straat
nvf rijden./ (omdat)/ Er/ waren stoplichten geplaatst/ voor het verkeer./ De straat was een stuk/ veiliger geworden./ De bewoners waren/ zeer te spreken/ over het resultaat.
verification:
vf In een straat met verkeersdrempels kunnen auto's niet hard rijden.
nvf In een straat met verkeerslichten kunnen auto's niet hard rijden.

7
Carina had/ via een postorderbedrijf/ een muziekinstallatie/ besteld. Na acht dagen/ werd de installatie/ afgeleverd./ Hij was klein/ en niet duur,/ precies wat ze wilde./ Ze besloot/ om/ hem te nemen/ en stuurde de meegeleverde acceptgiro op./ De bank/ voerde/ de betalingsopdracht
vf niet uit./ (omdat)/ Er/ was geen handtekening gezet/ op het formulier./ Ze
nvf niet uit./ (omdat)/ Er/ was een staking uitgebroken/ op het kantoor./ Ze kon het bedrag/ nu niet op tijd/ overmaken./ Ze hoopte/ dat de vertraging geen problemen/ op zou leveren.
verification:
vf Een betalingsopdracht zonder handtekening wordt niet uitgevoerd.
nvf Stakend bankpersoneel voert geen betalingsopdrachten uit.

8
De heer en mevrouw Steegs/ gingen naar Zuid-Frankrijk/ op vakantie. Met de caravan/ trokken ze/ met zijn tweetjes/ door het mooie land. Vandaag maakten ze/ een lange rit/ en mevrouw Steegs/ verveelde zich./ Ze wilde graag/ iets doen/ maar/ wist niet wat./ Ze kon/ tijdens de rit/ niet
vf lezen./ (omdat)/ Ze/ had gauw last van misselijkheid/ in de auto./ Bij de
nvf lezen./ (omdat)/ Ze/ had haar leesbril laten liggen/ op een camping./ Bij de volgende stop/ zou zij het stuur/ overnemen./ Dan moest ze/ daar maar/ op wachten.
verification:
vf Als je gauw last hebt van wagenziekte, moet je in een auto niet lezen.
nvf Als je je leesbril niet bij je hebt, kun je niet goed lezen.

9
Na een lange reis/ kwam de familie Peters aan/ in het Franse dorpje Beaune./ Ze waren/ op doorreis/ en zochten een plaats/ om te overnachten. Buiten het dorp/ vonden ze/ een hotel./ Meneer Peters/ ging naar binnen en meldde zich/ bij de receptie./ Ze konden/ in het hotel/ geen kamer
vf krijgen./ (omdat)/ Het/ was helemaal volgeboekt/ voor die nacht./ De
nvf krijgen./ (omdat)/ Het/ was voor onderzoek gesloten/ door de politie./ De receptionist/ verontschuldigde zich/ voor het ongemak./ Hij verwees meneer Peters/ naar een ander hotel/ niet ver daarvandaan.
verification:

vf In een volgeboekt hotel kun je geen kamer krijgen.
nvf In een afgesloten hotel kun je geen kamer krijgen.

10
Met lood in zijn schoenen/ ging Harm/ naar school./ Hij had die dag een proefwerk wiskunde./ Met lichte tegenzin/ ging hij/ het vierde uur naar het wiskundelokaal./ De leraar/ deelde zorgvuldig/ de opgaven uit/ en zei dat iedereen/ een uur/ de tijd had./ Harm kon/ geen enkele vraag/ goed
vf beantwoorden./ (omdat)/ Hij/ had erg slecht geleerd/ voor het proefwerk./ Hij
nvf beantwoorden./ (omdat)/ Hij/ had last van hoofdpijn/ tijdens het proefwerk./ Hij
hoopte/ dat hij het later/ nog kon compenseren./ Wiskunde was/ niet zijn slechtste vak.
verification:
vf Als je slecht hebt geleerd, kun je een proefwerk niet goed maken.
nvf Als je hoofdpijn hebt, kun je een proefwerk niet goed maken.

11
De Ronde van Vlaanderen/ was dit keer/ sterk bezet./ De organisatie had wielrenners/ van internationale allure/ aangetrokken./ De lange tocht werd/ in de massasprint/ gewonnen/ door een Italiaan./ Het was zijn eerste zege/ in een zo zwaar bezet veld./ Na de wedstrijd/ werd de Italiaan
vf gediskwalificeerd./ (omdat)/ Hij/ had doping gebruikt/ voor de race./ De
nvf gediskwalificeerd./ (omdat)/ Hij/ had een official omgekocht/ voor de race./ De
kranten maakten/ uitgebreid melding/ van het voorval./ De renner/ zou lang niet meer/ in wedstrijden/ mogen uitkomen.
verification:
vf Als je betrapt wordt op doping, word je gediskwalificeerd.
nvf Als je betrapt wordt op omkoping, word je gediskwalificeerd.

12
Cisca is/ in de zomer/ met een georganiseerde reis/ naar Thailand/ geweest. Ze ging eerst/ op trektocht/ door een natuurpark./ Daarna/ maakte ze een rondrit/ langs alle bezienswaardigheden./ In een bus/ trok de groep door het mooie land./ Ze had/ elke nacht/ veel moeite/ om/ de slaap te
vf vatten./ (omdat)/ Ze/ had last van de drukkende warmte/ in de tropen./ De
nvf vatten./ (omdat)/ Ze/ had last van vreemde geluiden/ in de tropen./ De
vakantie/ verliep verder/ zonder problemen./ Het was een ervaring die ze niet graag/ gemist zou hebben.
verification:
vf Als je last hebt van de warmte, is het moeilijk in slaap te komen.
nvf Als je last hebt van vreemde geluiden, is het moeilijk in slaap te komen.

13
Jaap ging/ deze morgen/ naar de tandarts./ Op twee plaatsen/ werden nieuwe vullingen/ aangebracht./ Hij moest/ naar huis/ om zijn spullen/ te halen/ voor school./ Toen hij thuis kwam,/ zette zijn moeder net/ koffie met cake klaar./ Hij nam/ de koffie/ met cake
vf niet./ (omdat)/ Hij/ had nogal veel last/ van zijn kiezen./ Hij pakte
nvf niet./ (omdat)/ Hij/ wilde op tijd zijn/ voor de les./ Hij pakte
snel zijn spullen/ en stapte weer/ op de fiets./ Gelukkig was de school/ dichtbij.
verification:
vf Bij kiespijn neem je geen koffie met cake.
nvf Bij haast neem je geen koffie met cake.

14
Mevrouw Wenders had/ een nieuwe jurk nodig./ Het was erg lang geleden/ dat ze kleren/ had gekocht./ In een drukke winkelstraat vond ze/ een aardig boetiekje./ Daar hing/ een mooie zijden jurk/ die haar ook/ goed paste./ Na enig getwijfel/ besloot ze/ de jurk/ niet te
vf nemen./ (omdat)/ De prijs/ was te hoog/ voor haar budget./ Gelukkig/ waren
nvf nemen./ (omdat)/ Hij/ kleurde slecht/ bij haar gezicht./ Gelukkig/ waren
er nog genoeg winkels/ om te gaan kijken./ Ze was vastbesloten om die dag/ te slagen.
verification:

vf Een te hoog geprijsde jurk koop je niet.
nvf Een slecht kleurende jurk koop je niet.

15
Pierre had/ de hele zomer/ doorgewerkt/ en was hard/ aan vakantie toe. Hij ging/ voor drie weken/ naar Portugal./ Nadat alles/ tot in de puntjes was geregeld/ vertrok hij/ naar Schiphol./ Daar aangekomen/ meldde hij zich/ bij de reisorganisatie./ Alle vluchten/ waren/ voor onbepaalde tijd
vf uitgesteld./ (omdat)/ Er/ was een dichte mist ontstaan/ op het vliegveld./ Hij
nvf uitgesteld./ (omdat)/ Er/ was een toestel neergestort/ op het vliegveld./ Hij
besloot/ om ergens/ koffie te gaan drinken./ Het zou wel even duren/ voor hij echt/ kon vertrekken.
verification:
vf Bij dichte mist op het vliegveld worden de vluchten uitgesteld.
nvf Bij een groot ongeluk op het vliegveld worden de vluchten uitgesteld.

16
De rijke man/ had zijn buren/ voor een kennismaking/ uitgenodigd. Hij woonde/ nog maar kort/ in de nieuwe buurt./ Hij bood hen/ eerst koffie aan/ en daarna/ liet hij/ zijn grote woning zien./ Hij gaf een rondleiding/ door bijna/ het hele huis./ De bovenste etage/ liet hij/ niet
vf zien./ (omdat)/ Hij/ had veel rommel liggen/ in die kamers./ De buren/ waren
nvf zien./ (omdat)/ Hij/ had een huurder zitten/ in die kamers./ De buren/ waren
erg onder de indruk./ Zij nodigden/ hem uit/ voor een tegenbezoek.
verification:
vf Rommelige kamers laat je bij een rondleiding niet zien.
nvf Onderverhuurde kamers laat je bij een rondleiding niet zien.

17
Angelique wilde/ samen met haar vriendin/ naar een popconcert gaan. Haar moeder/ had haar/ na lang zeuren/ het geld voorgeschoten. Het concert/ vond plaats/ in een groot stadion/ ergens in een buitenwijk/ van de stad./ Ze gingen/ naar het stadion/ en sloten aan in de rij/ bij de ingang./ Aan de kassa/ konden ze/ geen kaartjes
vf krijgen./ (omdat)/ Ze/ waren al uitverkocht/ in de voorverkoop./ De
nvf krijgen./ (omdat)/ Ze/ waren nog te jong/ voor een toegangsbewijs./ De
teleurstelling was/ op hun gezichten/ te lezen./ Nu ze dan eindelijk/ van thuis mochten,/ konden ze er/ niet in.
verification:
vf Als de kaartjes uitverkocht zijn, kun je er geen meer kopen.
nvf Als je voor een toegangsbewijs te jong bent, kun je er geen kopen.

18
Annelies had net/ haar eindexamen/ met succes afgelegd./ Haar ouders waren/ bijzonder trots/ op haar./ Ze zou/ in augustus/ een studie beginnen/ aan de universiteit/ van Groningen./ Tot die tijd/ had ze enkele maanden vrij./ Ze besloot/ om/ in elk geval/ een periode te
vf werken./ (omdat)/ Ze/ wilde geld verdienen/ voor een vakantie./ Samen
nvf werken./ (omdat)/ Ze/ wilde ervaring opdoen/ in een bedrijf./ Samen
met haar vriendin/ zou ze daarna/ op vakantie gaan./ Ze wilden een maand lang/ door Europa trekken.
verification:
vf Voor het verdienen van vakantiegeld moet je werken.
nvf Voor het opdoen van bedrijfservaring moet je werken.

19
Erik en Petra/ besloten eens/ uit eten/ te gaan./ Ze wilden/ dit keer iets nieuws proberen/ en hun keuze viel/ op een Japans restaurant/ bij hen in de buurt./ Om ongeveer zeven uur/ liepen ze/ de zaak binnen./ In de volle zaak ontdekten ze/ achterin/ een vrije tafel./ Ze konden/ aan die tafel/ niet plaats
vf nemen./ (omdat)/ Hij/ was door andere gasten besproken/ op die avond./ Voor
nvf nemen./ (omdat)/ Hij/ was door de chef vrijgehouden/ voor het personeel./ Voor
het wachten/ kregen ze/ aan de bar/ een drankje van de zaak./ Een dergelijke service/ hadden ze/ nog niet eerder meegemaakt.
verification:

vf Aan een reeds besproken tafel kun je niet plaatsnemen.
nvf Aan een tafel voor het personeel kun je niet plaatsnemen.

20
Elvira/ had problemen/ met haar geluidsinstallatie./ Haar cassetterecorder speelde wel goed af,/ maar/ nam niet meer op./ Ze besloot/ om hem/ naar een grote electronicazaak/ te brengen./ Daar werd/ een mankement/ aan één van de onderdelen/ geconstateerd./ De firma/ kon het toestel/ niet meteen
vf maken./ (omdat)/ Ze/ moesten het onderdeel bestellen/ bij de importeur./ Elvira
nvf maken./ (omdat)/ Ze/ hadden een grote achterstand/ in de werkplaats./ Elvira
zou waarschijnlijk/ een week/ moeten wachten./ Het bedrijf/ zou bellen als het toestel/ klaar was.
verification:
vf Als een onderdeel besteld moet worden, moet de reparatie wachten.
nvf Als de werkplaats een achterstand heeft, moet de reparatie wachten.

21
Jonas moest/ op school/ voor Duits/ een spreekbeurt houden. Hij wilde/ over de uitvinding/ van de fiets/ gaan spreken. In de Openbare Bibliotheek/ vond hij/ in de catalogus een geschikt boek./ Toen hij/ in de schappen zocht,/ kon hij/ het boek niet vinden./ Aan de balie/ vernam hij/ dat het boek/ niet aanwezig
vf was./ (omdat)/ Het/ was zojuist uitgeleend/ voor drie weken./ Hij
nvf was./ (omdat)/ Het/ was bij de boekbinder/ tot de volgende week./ Hij
besloot/ naar een andere bibliotheek/ te gaan./ Misschien had hij daar/ meer succes.
verification:
vf Als een boek uitgeleend is, kun je het niet lenen.
nvf Als een boek bij de boekbinder is, kun je het niet lenen.

22
Anouk besloot/ vrijdag/ naar de film/ te gaan./ Vroeg op de avond/ was ze te voet/ door het park/ naar de stad gelopen./ Na de film,/ die ze erg goed vond,/ dronk ze nog wat/ in het café./ Om twaalf uur/ ging ze weer naar huis./ Op haar terugweg/ vermeed Anouk/ de weg/ door het
vf park./ (omdat)/ Ze/ was bang voor aanranders/ in het donker./ Toen ze
nvf park./ (omdat)/ Ze/ had moeite goed te zien/ in het donker./ Toen ze
na een half uur/ thuis kwam,/ ging ze meteen/ naar bed./ Ze moest de volgende dag/ weer vroeg op.
verification:
vf Als je bang bent voor aanranders, moet je 's nachts parken vermijden.
nvf Als je 's nachts moeite hebt met zien, moet je donkere parken vermijden.

23
Arjen was/ met de auto/ op weg/ naar een vriend/ in Amsterdam./ Eenmaal in de stad/ aangekomen/ raakte hij al snel/ de weg kwijt./ Na wat rondgereden te hebben/ besloot hij/ een voetganger/ om hulp te vragen./ Hij zette zijn auto/ aan de kant/ en hield/ een meisje staande./ Ze kon hem/ helaas/ niet
vf helpen./ (omdat)/ Ze/ was totaal onbekend met de weg/ in de hoofdstad./ Bij
nvf helpen./ (omdat)/ Ze/ kon zich niet verstaanbaar maken/ in het Nederlands./ Bij
de volgende voetganger/ had Arjen/ meer succes./ Hij bleek nog een behoorlijk eind/ te moeten rijden.
verification:
vf Als je onbekend bent in een stad, kun je iemand de weg niet wijzen.
nvf Als je je niet verstaanbaar kunt maken, kun je iemand de weg niet wijzen.

24
Els zou/ een weekje/ naar vrienden/ in Londen gaan./ Ze verheugde zich/ op het weerzien/ met haar vrienden/ en op de indrukwekkende stad./ Ze nam/ op vrijdag/ de veerboot/ naar Engeland./ De boottocht verliep echter/ niet zonder problemen./ Els moest/ bijna vanaf het begin
vf overgeven./ (omdat)/ Ze/ had veel last van zeeziekte/ tijdens de reis./ In
nvf overgeven./ (omdat)/ Ze/ had iets verkeerds gegeten/ tijdens de reis./ In
Engeland aangekomen/ had ze/ een dag nodig/ om te herstellen./ Bij haar vrienden/ had ze daarna/ gelukkig nog/ een leuke tijd.

verification:

vf Als je veel last hebt van zeeziekte, moet je overgeven.

nvf Als je iets verkeerds hebt gegeten, moet je overgeven.

D Lengths of the materials of Experiments 5 and 6 (Chapter 4)

Lengths are in characters
vf = very familiar causal relation
nvf = not very familiar causal relation

	text		first clause	second clause		middle region		final region		verification	
nr	vf	nvf		vf	nvf	vf	nvf	vf	nvf	vf	nvf
1	401	403	36	51	49	27	25	14	14	44	57
2	404	410	38	50	56	26	25	14	21	42	48
3	421	423	51	54	55	24	30	19	14	56	68
4	399	387	55	45	42	21	18	13	13	44	49
5	415	423	40	51	58	18	23	18	20	62	67
6	422	426	39	51	54	24	27	17	17	66	65
7	431	428	45	54	52	27	27	17	15	64	57
8	408	411	33	52	55	31	30	11	15	70	60
9	447	453	42	49	54	23	27	15	16	50	50
10	422	426	45	52	55	22	22	19	22	65	60
11	445	451	51	43	50	19	26	13	13	58	60
12	432	432	52	55	55	32	32	13	13	66	73
13	379	375	32	46	41	19	18	16	12	42	39
14	397	395	51	44	42	11	14	17	17	40	39
15	434	433	52	55	54	28	27	17	17	63	69
16	391	390	37	47	47	22	22	14	14	55	60
17	472	474	45	48	51	20	17	18	24	60	66
18	406	404	49	48	46	20	21	18	15	51	52
19	472	474	43	56	60	33	31	13	19	54	57
20	439	436	43	58	55	31	28	17	17	65	67
21	429	433	55	49	53	22	21	16	21	50	57
22	411	410	52	48	47	24	23	14	14	69	72
23	441	445	30	56	60	30	32	16	18	67	73
24	440	439	42	53	52	27	26	16	16	55	54
M	423.3	424.6	44.1	50.6	51.8	24.2	24.7	15.6	16.5	56.6	59.1
SD	23.6	24.8	7.4	4.0	5.4	5.3	4.9	2.2	3.2	9.4	9.7

Samenvatting

In dit proefschrift werd onderzocht wat de invloed is van de kennis van de lezer en van het connectief *omdat* op de inferentiële verwerking van causale relaties in het domein van de algemene wereldkennis.

Een belangrijke vraag in het onderzoek naar inferenties is onder welke omstandigheden inferenties worden gemaakt tijdens het lezen (Hoofdstuk 1). Onderzoek naar de verwerking van causale relaties heeft aangetoond dat de kennis van de lezer een belangrijke rol speelt: lezers die kennis hebben van de inhoud van een causale relatie maken een causale inferentie, terwijl lezers die deze kennis niet hebben dat niet doen (Noordman & Vonk, 1992; Noordman, Vonk & Kempff, 1992; Simons, 1993). Simons (1993) vergeleek bijvoorbeeld het leesgedrag van economische experts met dat van leken ten aanzien van de verwerking van causale relaties in het kennisdomein van de economie. Hij constateerde dat experts een inferentie maakten maar leken niet. De bevindingen van deze studies waren gebaseerd op leesexperimenten waarin causale relaties werden gebruikt die behoorden tot zeer specifieke kennisdomeinen en waarin, met uitzondering van één experiment, alle causale relaties waren gemarkeerd door het connectief *omdat*.

De voorgaande onderzoeken werpen twee vragen op met betrekking tot de inferentiële verwerking van causale relaties. De eerste vraag heeft betrekking op de rol van de kennis van de lezer en de tweede op de rol van het connectief *omdat*.

De resultaten van Simons' (1993) onderzoek suggereren dat de kennis van de lezer over de inhoud van een causale relatie een alles-of-niets rol speelt, maar kennis zou opgevat kunnen worden als een gradueel begrip. Het zou kunnen zijn dat kennis in meer of mindere mate van invloed is. Dat impliceert dat inferenties in meer of mindere mate worden gemaakt afhankelijk van of kennis in meer of mindere mate beschikbaar is. Om dit te onderzoeken werd niet gekeken naar causale inferenties waarmee de lezer heel goed of helemaal niet bekend is maar naar causale inferenties die meer of minder voor de hand liggen. De vraag is of lezers een ander inferentieel gedrag vertonen voor inferenties over zeer voor de hand liggende causale relaties dan over inferenties over minder voor de hand liggende causale relaties.

De tweede vraag heeft betrekking op de rol van het connectief *omdat*. In de literatuur worden causale inferenties veelal onderzocht door de causale relaties te expliciteren middels het causale connectief *omdat*. In één experiment (Simons, 1993, Exp. 8) werd echter evidentie voor inferenties gevonden zonder dat de causale relaties waren geëxpliciteerd. In dat experiment waren de lezers economische experts die teksten lazen over economische onderwerpen. De vraag is of, onder normale leesomstandigheden, de aanwezigheid van het connectief een noodzakelijke voorwaarde is voor het maken van een causale inferentie.

De in het onderzoek gebruikte causale relaties behoren tot het domein van de algemene wereldkennis. De mate van bekendheid van de lezer met de causale relaties werd empirisch bepaald door middel van twee experimenten (Hoofdstuk 2). In het eerste experiment werd de deelnemers gevraagd om (zeer plausibele) oorzaken te bedenken voor zeer bekende gebeurtenissen die werden beschreven in korte teksten. De gegenereerde oorzaken werden vervolgens, ingebed in hun teksten, aangeboden aan een tweede groep deelnemers die de plausibiliteit van de oorzaken moesten beoordelen (Experiment 2). De twee experimenten resulteerden in 24 teksten over alledaagse onderwerpen in twee versies: met een zeer voor de hand liggende causale relatie (een zeer plausibele oorzaak) en met een minder voor de hand liggende causale relatie (minder plausibele oorzaak). De causale relaties waren gebaseerd op enthymema's, syllogistische redeneringen met een ontbrekende premisse. De inferentie bestond uit de ontbrekende (major) premisse. Bijvoorbeeld, in de zin *Jan ondervond een vertraging, omdat er een file was ontstaan*, waarin de minor premisse gevormd wordt door *er was een file ontstaan* en de conclusie door *Jan ondervond een vertraging*, bestaat de inferentie uit de missende major premisse *een file leidt tot vertraging*.

In Hoofdstuk 3 werden twee modellen van verwerking voorgesteld met betrekking tot de invloeden van de kennis van de lezer en de aanwezigheid van het causale connectief *omdat* op het maken van causale inferenties. Het eerste model veronderstelt dat het hier gehanteerde onderscheid in bekendheid overeenkomt met expert- versus lekenkennis. Volgens dit model zullen inferenties gemaakt worden als de causale relatie erg voor de hand ligt ongeacht de aanwezigheid van het causale connectief *omdat*. Als de relatie niet zo voor de hand ligt, zullen er geen inferenties worden gemaakt en ook daarbij speelt de aanwezigheid van het connectief geen rol. Het tweede model veronderstelt dat het onderscheid in bekendheid van de causale relatie op te vatten is als twee niveaus van expertkennis. Dit model voorspelt dat inferenties worden gemaakt in de conditie met zeer voor de hand liggende causale relaties ongeacht de aanwezigheid van het connectief. In de conditie met minder voor de hand liggende relaties wordt verwacht dat het connectief wel een rol speelt. De aanwezigheid van het connectief geeft de lezer juist voldoende informatie om de inferentie te maken, hetgeen bij afwezigheid ervan niet gebeurt.

Er werden twee leesexperimenten uitgevoerd om deze modellen te toetsen. In Experiment 3 werden woordherkenningstijden, verificatietijden en leestijden gemeten. De deelnemers van het experiment lazen teksten waarin een causale relatie was opgenomen die varieerde in bekendheid en die wel of niet gemarkeerd was door het connectief *omdat*. De teksten werden regel-voor-regel aangeboden waarbij de lezers op een knop drukten om door te tekst te gaan. Tijdens het lezen werd een woord aangeboden waarvan de lezers moesten bepalen of het letterlijk in de tekst had gestaan. Het herkenningswoord, dat afkomstig was van de eerste deelzin van de causale relatie, werd getoond na het lezen van de tweede deelzin. In het geval er een inferentie wordt gemaakt zal de lezer de tweede deelzin verbinden aan de eerste met als gevolg dat de eerste deelzin gereactiveerd wordt in het geheugen. Dit zal de herkenningstijd versnellen, aangezien het woord dan geactiveerd is in het geheugen. De woordherkenningstijden geven aan of er een inferentie is gemaakt. Na het lezen van elke tekst moesten de deelnemers een verificatiezin op zijn juistheid beoordelen. De verificatiezin bestond uit de inferentiële informatie. Als de inferentie tijdens het lezen is gemaakt en de inferentiële informatie dus beschikbaar is, zal de beoordeling van de verificatiezin eenvoudig zijn en snel verlopen vergeleken met de situatie waarin de inferentie niet is gemaakt. De leestijden, tenslotte, zullen een toename laten zien als er een inferentie is gemaakt, omdat het maken van inferenties tijd kost. De voorspellingen ten aanzien van deze maten voor de twee modellen waren als volgt. Het expert-versus-lekenkennismodel voorspelde een hoofdeffect van bekendheid in de woordherkenningstijden en geen effect van het connectief noch een interactie tussen bekendheid en connectief op de drie maten. Het twee-niveaus-van-expertkennismodel voorspelde voor alle drie maten een interactie tussen bekendheid en connectief die toe te schrijven zou zijn aan een invloed van het connectief op de verwerking van alleen de niet zo voor de hand liggende causale relaties.

De resultaten waren met geen van de twee modellen van verwerking in overeenstemming. De verificatietijden lieten een effect van het connectief zien in beide bekendheidscondities: de verificatietijden waren korter als het connectief aanwezig was. De woordherkenningstaak vertoonde kortere herkenningstijden wanneer het connectief aanwezig was, maar dit was alleen zo bij de zeer voor de hand liggende causale relaties. Verder was er geen hoofdeffect van bekendheid. De leestijden tenslotte vertoonden geen interactie-effect tussen bekendheid en aanwezigheid van het connectief. De resultaten van de verificatietaak en, deels, de resultaten van de woordherkenningstaak suggereerden dat inferenties waren gemaakt als het connectief aanwezig was.

Ervan uitgaande dat de verificatietijden in Experiment 3 evidentie gaven in beide bekendheidscondities voor het maken van inferenties onder invloed van de aanwezigheid van het connectief was het vreemd dit hoofdeffect niet te vinden in de woordherkenningstijden en de leestijden. Experiment 4 werd opgezet om te toetsen of door vereenvoudiging van de experimentele opzet en door het meer voor de hand liggend maken van de causale relaties de gevoeligheid van de woordherkenningstaak kon worden verbeterd. De leestaak in Experiment 4 was dezelfde als die in Experiment

3, maar de verificatietaak werd verplaatst naar het einde van het experiment om de complexiteit van het experiment voor de deelnemers te verminderen en in de teksten werd vóór de causale relatie een zin opgenomen die de oorzaak in de causale relatie meer voor de hand liggend maakte. De resultaten van de woordherkenningstaak ondersteunden nu de resultaten van de verificatietaak in Experiment 3. Er was een hoofdeffect van de aanwezigheid van het connectief: de woordherkenningstijden waren korter als het connectief aanwezig was.

Tezamen ondersteunden de experimenten de assumptie dat inferenties werden gemaakt als het connectief aanwezig was. Er werd evidentie gevonden voor het maken van inferenties in beide bekendheidscondities, hetgeen betekent dat inferenties werden gemaakt ongeacht de mate van bekendheid met de causale relaties. Dit resultaat werd echter uitsluitend gevonden in de verificatie- en de woordherkenningstijden, de leestijden vertoonden het effect niet. Een belangrijk kenmerk van de leestaak in beide experimenten was dat de leestijden regel voor regel werden gemeten. De leestijden gaven derhalve de verwerkingsduur van gehele deelzinnen weer. Een verklaring voor het niet vinden van een toename in de leestijden werd gezocht in twee mogelijke functies van het connectief *omdat* die elk een ander effect op de leestijden hebben. Aan de ene kant nodigt het connectief uit tot het maken van een inferentie hetgeen resulteert in langere leestijden. Aan de andere kant signaleert het connectief hoe de twee deelzinnen geïntegreerd moeten worden, namelijk dat er een causaal verband gelegd moet worden tussen de tweede deelzin en de eerste. Er is ondersteuning in de literatuur voor de veronderstelling dat deze integratieve functie van het connectief het leesproces versnelt (Haberlandt, 1982; Millis, Golding & Barker, 1995; Millis & Just, 1994; Sanders & Noordman, 2000). Het niet vinden van een effect van het connectief *omdat* op de leestijden zou daarom verklaard kunnen worden door te veronderstellen dat de twee functies van het connectief *omdat* elkaar hebben opgeheven.

In Hoofdstuk 4 werden twee experimenten beschreven waarin de leestijden op een nauwkeurigere manier werden gemeten en waarin de hypothese over de twee functies van het connectief *omdat* werden getoetst. Experiment 5 gebruikte dezelfde aanbiedingsmethode als Experimenten 3 en

4 maar de grootte van het aanbiedingsvenster werd verkleind van een deelzin tot één of meerdere woorden. Door de teksten in kleinere eenheden aan te bieden was het mogelijk de leestijden te meten op gedeeltes van de zinnen. De verwachting was dat de effecten van de twee functies van het connectief *omdat* zich zouden voordoen op verschillende plaatsen gedurende de verwerking van de causale relaties. Aangezien integratie verwacht wordt plaats te vinden tijdens de verwerking van de woorden van de tweede deelzin en een inferentie pas nadat de gehele deelzin is gelezen, werd voorspeld dat de verwerking van de woorden die onmiddellijk volgen op het connectief zou worden versneld en de verwerking van het laatste gedeelte van de zin zou worden vertraagd indien de causale relatie zou zijn gemarkeerd door het connectief *omdat*. De resultaten van de leestijden bevestigden deze hypothese. De woorden die onmiddellijk volgden op het connectief werden sneller gelezen en de woorden aan het einde van de zin werden langzamer gelezen als het connectief aanwezig was. Daarnaast werd het effect van het connectief *omdat* op de verificatietaak, zoals gevonden in Experiment 3, gerepliceerd. Verificaties werden sneller beoordeeld als het connectief aanwezig was.

Experiment 6 repliceerde de resultaten van de leestijden van Experiment 5 met een methode die meer in overeenstemming is met hoe mensen onder normale omstandigheden lezen. De oogbewegingsregistratiemethode laat toe dat teksten in hun geheel worden getoond en dat lezers, indien gewenst, terug kunnen kijken in de tekst. Bovendien is het voor het lezen van de tekst niet vereist dat op een knop wordt gedrukt. De leestijden werden berekend voor delen van de tekst door opeenvolgende fixaties en hun tussenliggende saccades op te tellen. De berekeningen werden alleen gemaakt voor de eerste lezingen van tekstgedeeltes. Een eerste lezing betekent dat een tekstgedeelte niet bij een eerdere doorgang mocht zijn gelezen of zijn overgeslagen. De berekening startte bij de eerste fixatie op het tekstgedeelte en eindigde bij de laatste fixatie op het tekstgedeelte voordat het in voorwaartse richting werd verlaten. Er werden twee soorten leestijden gebruikt: de gesommeerde fixatie- en saccadetijden behorende bij die gevallen waarin de lezer niet eerst terugspringt in de tekst alvorens het lezen in voorwaartse richting te vervolgen ('first pass forward reading times') en de leestijden behorende bij de eerste lezing van een tekstgedeelte waarbij de lezer al dan niet eerst terugspringt in de tekst alvorens het lezen in voorwaartse richting te vervolgen ('first pass regression path durations'). De tweede soort leestijd bevat dus ook de tijd die gespendeerd wordt aan het terugspringen in de tekst. De analyses van de beide soorten leestijden ondersteunden de resultaten van Experiment 5. Er werd een faciliterend effect van het connectief *omdat* gevonden op de verwerking van de woorden die onmiddellijk volgden op het connectief en een vertragend effect op de woorden aan het einde van de zin.

In Hoofdstuk 5 werd ingegaan op twee methodologische aspecten van de leestijdenmeting in Experiment 6. Het eerste aspect had betrekking op regressies, oogbewegingen die behoren bij sprongen terug in de tekst. Regressies worden beschouwd als indicatief voor het optreden van problemen tijdens de verwerking: de lezer stuit op een probleem en zoekt de oplossing daarvoor in een reeds eerder gelezen gedeelte van de tekst. De leestijden onmiddellijk voorafgaand aan een terugsprong zijn in de meeste gevallen relatief kort. Wanneer men de leestijden van een tekstgedeelte berekent, vormen de gevallen waarin een regressie wordt gemaakt een probleem. Omdat de leestijd vlak voor een terugsprong relatief kort is en niet weergeeft hoe lang de lezer doet over de oplossing van het probleem dat is opgeroepen door het tekstgedeelte waarvandaan wordt teruggesprongen, resulteert de berekening van de leestijden van dit tekstgedeelte in een onderschatting van de werkelijke verwerkingstijd. Deze onderschatting kan voorkomen worden door alle gevallen waarin de verwerking van een tekstgedeelte wordt afgesloten met een regressie uit te sluiten van de berekening van de verwerkingstijd van dat tekstgedeelte. Deze maat van verwerking werd gebruikt in Experiment 6 en werd 'first-pass *forward* reading times' genoemd. Daarnaast werd in het experiment de maat 'first-pass regression path durations' gebruikt waarin de gevallen waarin een regressie wordt gemaakt wel zijn meegenomen.

Het tweede methodologische aspect was gerelateerd aan de rol van saccades in de berekening van leestijden die op oogbewegingen zijn gebaseerd. Het is gangbaar in het leesonderzoek om de leestijden die van oogbewegingen zijn afgeleid te baseren op de som van alleen de opeenvolgende fixaties op een woord of een groep van woorden. De duur van de saccades die zich tussen de fixaties bevinden wordt buiten beschouwing gelaten. In

Hoofdstuk 5 werd gesteld dat deze procedure niet correct is. In overeenstemming met Irwin's (1998) bevinding dat lexicale verwerking ongestoord doorgaat tijdens het maken van een saccade werd aangetoond dat analyses van geaggregeerde saccadetijden dezelfde resultaten te zien gaven als de analyses van de leestijden in Experiment 6. Bovendien resulteerden de analyses van de leestijden in Experiment 6 waarin de saccadetijden waren opgenomen in grotere effecten dan de analyses van de vergelijkbare maten waarin de saccadetijden waren geëxcludeerd. Er werd derhalve geconcludeerd dat saccadetijden net als fixatietijden een bijdrage leveren aan de leestijd en dat zij moeten worden opgenomen in geaggregeerde maten van verwerking.

In Hoofdstuk 6 werd een samenvatting gegeven van het onderzoek en werden de belangrijkste conclusies besproken. De conclusies hadden betrekking op de gehanteerde methoden van onderzoek, de invloed van de beschikbaarheid van de kennis van de lezer op het maken van inferenties, de rol van het connectief *omdat* tijdens de verwerking van causale relaties en de processen van integratie en inferentie.

Methode. De twee methoden van leesonderzoek die in de experimenten zijn gebruikt, t.w. de druktijdenmethode met een non-cumulatieve aanbieding van delen van de tekst (in Experimenten 3, 4 en 5) en de oogbewegingsregistratiemethode (in Experiment 6), werden in Hoofdstuk 6 vergeleken. De twee onderzoeksmethodes produceerden dezelfde resultaten met betrekking tot de bestudeerde leesprocessen. Op grond van het feit dat de druktijdenmethode eenvoudiger is, zou men kunnen concluderen dat deze de voorkeur verdient boven de meer complexe oogbewegingsregistratiemethode. Er werd echter opgemerkt dat de specifieke tekortkomingen van de druktijdenmethode de generaliseerbaarheid van de resultaten naar het normale leesproces bemoeilijken. Bij de oogbewegingsregistratiemethode is dat veel minder het geval. Deze methode maakt het mogelijk het natuurlijke leesproces te bestuderen op een niet-indringende, gedetailleerde en diepgaande manier. De conclusie was derhalve dat de oogbewegingsregistratiemethode, ondanks de grotere inspanning die nodig is om de data te verzamelen, een meer geschikte methode is om leesonderzoek te doen dan de druktijdenmethode.

Het huidige onderzoek draagt bij aan de ontwikkeling van de oogbewegingsregistratiemethode door een nieuwe maat voor te stellen die uitdrukking geeft aan de doorgaande, voorwaartse verwerking van tekst en door aan te tonen dat de duur van saccades in de berekening van de leestijden moet worden opgenomen.

Beschikbaarheid van kennis en inferenties. Ervan uitgaande dat de twee niveaus van bekendheid met de causale relaties een hoge en een lage beschikbaarheid van kennis reflecteerden (Hoofdstuk 2), liet de bevinding dat de twee niveaus niet differentiëerden met betrekking tot inferentiële verwerking zich moeilijk rijmen met de graduele visie op het maken van inferenties zoals verwoord door Kintsch (1988) en McKoon and Ratcliff (1992). De graduele visie op inferentiële verwerking kwam voort uit onderzoek naar inferenties over voorspelbare gebeurtenissen: hoe meer evidentie wordt verzameld voor een dergelijke inferentie, des te sterker zij wordt. Volgens de minimalistische hypothese over inferenties (McKoon & Ratcliff, 1992; McKoon & Ratcliff, 1995), die stelt dat inferenties tijdens het lezen worden gemaakt afhankelijk van de sterkte van hun bijdrage aan de locale coherentie of van de beschikbaarheid van de kennis van de lezer, zou de bekendheid van de lezer met de inhoud van de causale relatie, zoals geïmplementeerd in het huidige onderzoek, een gradueel effect moeten hebben laten zien op het maken van inferenties. Dit was echter niet het geval. De resultaten van het huidige onderzoek lieten zich beter verklaren vanuit een alles-of-niets visie op inferentiële verwerking. Volgens deze visie, die de laatste twintig jaar opgeld doet in het inferentieonderzoek, wordt een inferentie gemaakt of niet gemaakt.

Het onderhavige onderzoek bood ondersteuning voor een alles-of-niets visie op het maken van inferenties. De kwestie of inferenties gradueel dan wel op een alles-of-niets wijze worden gemaakt is daarmee echter niet beslist. Verder onderzoek moet duidelijk maken onder welke omstandigheden welke inferenties geheel dan wel gedeeltelijk gemaakt worden.

De rol van het connectief. Het huidige onderzoek naar de verwerking van causale relaties in het domein van de algemene wereldkennis liet zien dat zelfs wanneer lezers kennis hebben over de inhoud van een causale relatie, de aanwezigheid van het connectief *omdat* een noodzakelijke voorwaarde is om de causale inferentie te maken. De inferentie wordt gemaakt om een causale relatie te rechtvaardigen. Dat vereist een extra inspanning maar resulteert in een beter begrip van de tekst. Het feit dat geen enkele evidentie werd gevonden voor het maken van een inferentie als het connectief niet aanwezig is, is strijdig met eerdere bevindingen. In eerder onderzoek werd evidentie gevonden voor het maken van causale inferenties bij afwezigheid van het causale connectief. Gesteld werd dat in deze studies de experimentele opzet het maken van inferenties uitlokte, hetzij door de taak (Keenan, Baillet & Brown, 1984; en anderen), hetzij door de expertise van de deelnemers (Simons, 1993), maar dat daarvan in dit onderzoek geen sprake was. De experimentele opzet van dit onderzoek was meer in overeenstemming met wat lezers onder normale omstandigheden doen en geconcludeerd werd dat, onder normale leesomstandigheden, het maken van een causale inferentie in het domein van de algemene wereldkennis afhangt van de kennis van de lezer over de inhoud van de causale relatie én van de aanwezigheid van een causaal connectief.

Integratie en inferentie. In de experimenten werd evidentie gevonden voor twee verschillende effecten van het connectief *omdat* op de verwerking van causale relaties. Het had een faciliterend effect op de verwerking van de woorden die onmiddellijk volgden op het connectief en een vertragend effect op de verwerking van de laatste woorden van de zin. Het eerste effect werd toegeschreven aan het proces van integratie en het tweede effect aan het proces van infereren. De integratie bestaat uit het leggen van een causaal verband tussen de twee deelzinnen. Het connectief signaleert dat de tweede deelzin te interpreteren is als de oorzaak voor de eerste deelzin. Wanneer deze informatie is gegeven, valt de noodzaak bij de lezer weg om de aard van de relatie zelf te bepalen hetgeen de verwerking van de woorden in de zin vergemakkelijkt. Het inferentieproces bestaat uit het toetsen van de inhoud van de causale relatie tegen de eigen kennis. Het voordeel hiervan is een beter begrip van de tekst. Indien de inferentie niet wordt gemaakt betekent dit dat de causale relatie als vanzelfsprekend wordt aangenomen. De twee leesprocessen kunnen gerelateerd worden aan de totstandkoming van verschillende niveaus van tekstrepresentatie (Noordman & Vonk, 1997). Het integratieproces draagt bij aan de totstandkoming van de propositionele representatie en het inferentieproces aan de totstandkoming van de mentaal model representatie.

De bevindingen van het onderzoek kunnen goed geplaatst worden in de theorie van tekstverwerking gebaseerd op de verschillende niveaus van tekstrepresentatie. Deze theorie is tot op heden voornamelijk gebruikt om geheugenaspecten van tekstverwerking te beschrijven. De koppeling van de verschillende leesprocessen aan verschillende niveaus van representatie brengt het model één stap verder en zal hopelijk leiden tot een beter begrip van het complexe proces van tekstverwerking.

Curriculum Vitae

Reinier Cozijn (1957) studied Experimental Psychology at the University of Nijmegen. During his study, he worked as a teaching assistant to dr. F. Maarse, teaching programming in Pascal, and as a research assistant to prof. dr. W. Vonk, at the Max Planck Institute for Psycholinguistics (Nijmegen), conducting psycholinguistic experiments. After graduation in 1990 (on the subject of the influence of semantic and pragmatic context on the processing the lexical ambiguities), he accepted a Ph.D.-position at the Discourse Processes Group of the Faculty of Arts of Tilburg University. Supervised by prof. dr. L.G.M. Noordman (Tilburg University) and prof. dr. W. Vonk (University of Nijmegen and Max Planck Institute, Nijmegen), he wrote a dissertation on the topic of inferential processes during reading. He currently is working at Tilburg University as head of the computer department of the Faculty of Arts, a position he obtained in 1993.